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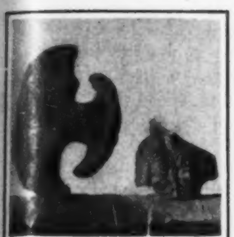


A Votive axe in pottery.

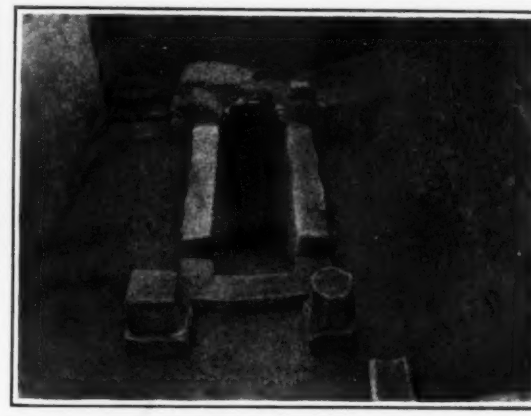
A panoramic view of the excavated area in the north of the Royal City.

Bronze scepter head.

Shrine of the Royal City, a short distance outside the walls to the south, showing the two stelae, or tablets bearing inscriptions, which are believed to be the best continuous Ethiopian inscriptions yet discovered.

A wooden model illustrating the plan of the sun temple, with the fore part as a sun-dial.

A cameo of onyx with galloping horses, to represent day and night—Greek of B. C. 250.



Observatory, showing two observation stones and wall of grafitti and steps to tank. The baths in the tank are shown in another illustration. Meroë will soon be covered by the waters from the Assouan dam.

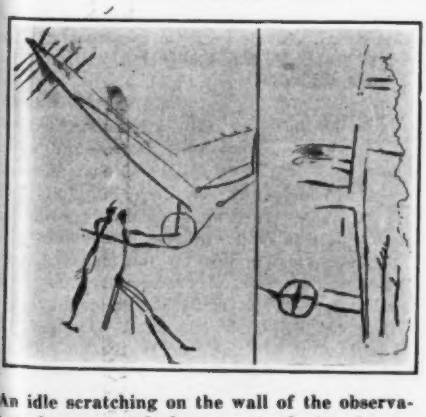
Fittings from the royal throne—B. C. 500.

A bath in observatory building. (Plan showing locations of baths.)

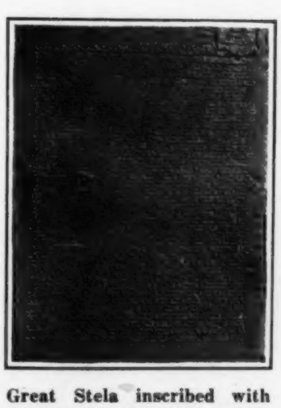
An altar with a fetish.

A stone recording observed angles.

A bath recently discovered in the street leading into the "palm" court.

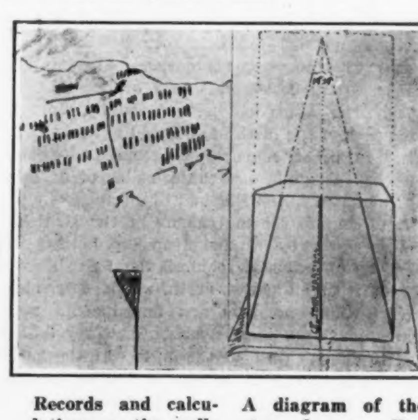


An idle scratching on the wall of the observatory by some onlooker or attendant: An astronomer and his transit instrument.



Great Stela inscribed with 42 lines of Meroitic writing that has not been deciphered.

A graffitto giving astronomical calculations and a record of observations.



Records and calculations on the walls of the observatory.

A diagram of the stone for recording observed angles.

An ancient center of astronomical science.

MEROË, THE ROYAL CITY OF ETHIOPIA.—[See page 98.]

Meroë the Royal City of Ethiopia

Important Discoveries that Indicate Advanced Knowledge of Arts and Sciences

Located on the River Nile in southern Nubia, the region of Ethiopia of olden times, was the city of Meroë, which has long been the scene of much archaeological investigations, as it has yielded many antiquities that have thrown much light on the history of forgotten races and nations, and their foreign relations and influences (at first Egyptian, then Hellenistic-Greek and subsequently Roman, with reason to believe that evidences of still other races will be discovered) which dominated their development. During the past season valuable discoveries were made, which were described in the *London Illustrated News* by Prof. John Garstang, of the Institute of Archaeology at the University of Liverpool, and many of the objects recovered that were exhibited in London were illustrated in the above publication, from which our illustrations and information are derived.

These objects illustrate the character of Ethiopian culture from the establishment of the court at Meroë in the sixth century B. C. to the destruction of the city in the third century A. D.; but one of the most important results of the explorations has been the proof that the city of Meroë was a center of astronomical science of no small importance. The description by Prof. Garstang of the discoveries is as follows:

The season 1914 has advanced our work in the royal city at Meroë to a penultimate phase. We have now been able to connect up the various areas in which we have been excavating for some years, and to uncover completely the northwestern corner; so that the whole of the northern portion of the city has now been brought to view. It only remains to uncover and enclose the southern portion to bring the excavation of this central feature of the site to completion. The Sudan Government has already instituted a convenient service of trains and accommodation for visiting this ancient capital of the country.

The buildings of the later portions of the Middle Meroitic period (circa B. C. 150) reveal the city at its prime. The main entrance through the northern wall led on through an avenue of trees towards the center of the city, where on the left hand or eastern side there seems to have stood a public building fronting or replacing the now time-honored portico which had stood there, it would seem, in the sixth or seventh century B. C. Almost opposite was an indefined building of solid foundation, which, to judge from the records of observation and calculation found along its western side, may indeed at that time have been an observatory and residence of an astronomer. The palace of these times lay immediately to the left of the main gateway: a large building, with central courtyard and veranda. Opposite the palace in this quarter is the enclosure, which seems to have been walled off as a place for interring the cremated dead. The crematorium itself has been found in the building at the head of the street last mentioned: the flues and hearth still remain, and the floor was found littered deep with partly incinerated bones.

While the development of the general plan has not been without its measure of surprises, it has nevertheless much simplified and amplified our provisional chronology. The fact that the early gateway and the secondary gateway through the northern wall were obviously in contemporary use, being linked together by the palace of Neteg-Amon and the road-system around this building, led us *inter alia* to the inevitable conclusion that the main city wall was built at the beginning of our Hellenistic Period in the early third century B. C. Some buildings thus pre-existed the main city wall, which was only raised around the area some centuries after these had been built.

There is evidence to show not only that there was a place and equipment for astronomical observations at Meroë in the second century B. C., but also that it was in close proximity to this building; for on what was then the outside western wall we found a number of graffiti representing both calculations or record of observations and actual sketches of two instruments which would seem, so far as they can be understood, to correspond to a transit instrument with circle and an azimuth instrument.

A special flight of steps subsequently disused seems to have led down from that side of the building to the outer level where these graffiti and other features are to be found. The other material evidence consists in the remains of two columns or pedestals. One of these columns is hexagonal, the other square. The latter is carefully set upon a stone plinth in such fashion that certain markings on its side correspond exactly to marks upon the base; and the alignment is controlled, it would seem, from a sighting point upon the further side of the hexagonal column. This alignment is still true, and its bearing east of magnetic north is 128½ degrees. The magnetic deviation lies probably between 2½ degrees and 3 degrees west at the present time.

Upon the face of the square column which is turned towards the other, that is, its western face, there are engraved three lines which, if produced upwards, would meet more or less accurately in a point. The outer lines converge upon the middle line so as to make angles in each case of approximately 14 degrees. The middle line is not (at the present time at any rate) truly vertical, but is inclined at an angle of approximately 3¼ degrees, the bottom of the line being to the south of the point vertically below the point of intersection of the three lines in question. This face of the stone is not set in the meridian, nor is it quite true in its own plane. Its bearing along the bottom is 37½ degrees east, and along the top 40½ degrees. There is a possibility of error in our record of these details amounting to about ± ¾ degrees.

We have thought it best to publish these bare facts because astronomers everywhere cannot fail to be interested in the obvious significance not only of this diagram, but of the calculations and the designs upon the wall.

The latitude and longitude of Meroë, determined 3 years ago, are 16 degrees 56 feet 18 inches North, 33 degrees 44 feet 15 inches East, and it will be noticed at once that the inclination of the southernmost of the three lines to the vertical upon the square column almost corresponds with the latitude.

There are many interesting records in the pages of Pliny, and some in other writers, all tending to show that the astronomers of the second and third centuries B. C. made consistent observations at various points in and about the Nile basin with a view to determining latitude and other astronomical data. It is related, suggestively, that at Ptolemais, which was on the Red Sea coast, very nearly in the latitude of Meroë, an interval of 45 days elapsed between the summer solstice and the two dates (before and after) whereon the shadows of the sun were vertical at noon (Pliny's "Natural History,' II., 75—VI., 34). Now the graffiti of the wall include the calculation or record of a series of observations which will be seen to involve the number of forty-five on each side of an equation, with a difference at the foot on one side of three, and on the other side of ten. This summation of figures is represented in units arranged in five groups of three, and in three lines in each case, and it is obviously suggested that it is really the record of observations kept daily, and that 45 days on each side was the basis of calculation. Pliny tells us, significantly, that at Ptolemais, which is approximately on the same latitude as Meroë, the shadow of the sun was vertical *45 days before and after* the summer solstice.

There is another significant feature about the position of these astronomical monuments, for we are told that when at the end of the third century B. C. Eratosthenes determined the latitude of Assouan and the size of the earth, he made use of a deep well for the purpose of his observations. The date of our monuments is, however, more nearly that of Hipparchus, who is credited with many improvements and additions to astronomical instruments.

Outside the city we made further experimental examination of three spots, including a number of prominent mounds located along the south side of the Temple of Amon.

One other site was examined, an isolated mound lying some 2 or 3 kilometers to the south, not far from the village of Hamadab. The most immediate result was the discovery of two great stelae, inscribed in Meroitic cursive characters, both apparently historical narratives. A few hours' work showed the important nature of the inscriptions.

The two stelae are of the characteristic dark grit used anciently in this locality for special purposes, such as altars, steps, thresholds, and the like. They were found left and right of the entrance to the shrine mentioned, facing outwards towards the west. The larger and more perfect inscription was on the left (or north side). The stone itself is 2.58 meters in height, with a maximum width of 1.16 meters, and weighs 3½ tons. The inscription fills 42 completed lines, 4 lines at the bottom being blank, covering a height of 141 centimeters below the sculptures on the dressed face of the stone.

The Engineer in the Field

The Marquis of Graham delivered his presidential address recently before the Junior Institution of Engineers, Sir Boverton Redwood, Bt., in the chair. He took as his text, "The War and Engineering," and remarked that war had become very largely a matter of engineering. If Attila's army of 700,000 Huns were excepted, no warrior had hitherto had more than 60,000 troops to transport, maneuver, and maintain. The Kaiser to-day boasted his four or five millions of all arms. The Allies had legions equally numerous, and from each of the farthest ends of the world Britons had come in great convoys of steam transports, which dwarfed in significance the armadas of Athens, Carthage, and Rome, and England of old.

Referring to the movements of the British Expeditionary Forces by rail and steamship, Lord Graham said that the government required the British railways to collect from all parts—north, south, east, and west—troops whose numbers and impedimenta needed 350 trains, made up, on an average, of thirty vehicles each, and to detrain them at the ports of embarkation within forty-eight hours. This great feat was accomplished. As was now well known, most of the troops left from Southampton, and for weeks trains were passed over the lines during the night at the rate of five trains per hour. Such a performance was not only creditable to the organization of the railways, but proved that the mechanical equipments and direction of the port were most efficient. To tackle the troops, horses, guns, limbers, and other accessories of battalions arriving in seventy-three trains within fourteen hours on successive nights was an unprecedented feat. It was right, however, that similar credit should be given to the harbor authorities at Marseilles, where twenty-eight vessels with our Indian troops and their munitions of war were dealt with in twenty-four hours. Remarkable work, too, had been done by the Russian railway authorities.

Motor vehicles played a great part, secretly and silently, in the transfer of the British army from their trenches 100 yards in front of the enemy on the slopes in the Aisne Valley, during the night of October 20, to the new battle front on the Yser. Such an unexcelled strategic movement by a great army would have been almost impossible without motor conveyances in addition to railways.

Great improvements had been made in guns, and the rate of fire was at least 100 times faster than of old. The German 16½-inch howitzer, firing a 1¼-ton shell, was, for transport purposes, taken apart to make four separate loads, and none of these, including its carrier, weighed more than 25 tons. Each was hauled by three road tractors, with reserves for supplementing the tractive effort through cables and drums on inclines or hilly ground.

In the first six weeks of the war British aeroplanes flew an average distance of 2,000 miles a day, and nothing was hidden from the observer in the flying machine. For instance, an airman at an altitude of 12,000 feet above London could, if the weather conditions were favorable, scan the whole coast line from Portsmouth to Yarmouth, and see even the shore cliffs of France beyond.—*The Daily Telegraph.*

Monorail Electric Cranes

Of late the European electrical industry is furnishing an interesting type of monorail crane, as it is called, in the shape of an electric carriage traveling upon a structural iron beam. Such a construction will often be most convenient, especially upon building sites or within works where space is limited and materials need to be handled rapidly over considerable distance. The Oerlikon monorail carriages run suspended from the lower web of an I-beam or a pair of assembled channel bars. Such a crane will answer for unloading railroad cars, and it takes the place of small surface cars with the advantage that no rails on the ground or turntables are needed. To the carriage is fixed an iron frame support with seat for the operator, who works the controller for the main motor and for the lift motor. Translation of the carriage can also be done by hand. One point to be noticed is that the lift motor drives the cable drum by the recently-introduced endless screw speed-reduction method which we described previously; and it has the advantage of silent running, for the additional reduction gear which is here needed runs at slow speed. Since its introduction, the Oerlikon endless screw method has proved quite a success for speed reducing in this and other apparatus. Motors of continuous or three-phase current type take current by small trolley from wires running alongside.

Wireless Telegraphy*

A Review of Some Notable Developments of the Past Year

When Sir Ernest Shackleton left England in October with the object of crossing the Antarctic continent from the Weddle Sea to the Ross Sea, he took with him a wireless telegraph station having a range of about 500 miles. Apparently it is not Sir Ernest's intention to use wireless telegraphy on his ship, but there is no doubt that it will be a valuable resource to members of the sledge party in enabling them to communicate with the base. Early in the year it was announced that the Postmaster-General had consented to a license being granted to Marconi's Poldhu station for the purpose of conducting a commercial wireless telegraph service between England and Spain. In January wireless telegraphy played an important part in the saving of life at sea, but for reasons of space we cannot do more than make a passing mention of one notable instance—that of R.M.S. "Colequid," which went ashore on the Trinity ledges in the Bay of Fundy. If the vessel had been unable to send out its appeal for help far and wide all on board would have been lost, for, even as it was, it was not easy to find the wreck in the midst of the wintry storm in a bay where the rise and fall of the tide is greater, perhaps, than in any other part of the world, amounting to between 60 feet and 70 feet. But for wireless telegraphy it is undeniable that the situation would have been hopeless.

When the new chain of wireless stations now in course of construction by the Canadian government is finished and in operation, it will be possible for a passenger on any incoming steamship to communicate from mid-ocean as far inland as Fort William. All down the river and gulf the government stations are in regular operation.

The Marconi Company has been engaged for some time in the design of wireless telegraphy for air craft, and during the past year experiments were carried out at Hendon, and there is good reason to believe that the Marconi apparatus in its latest stage of evolution will meet the demands of naval and military authorities.

Finisterre, Santander, and Cape Palos must now be marked on the map of the world with a sign that denotes the existence of a wireless station. All three stations have now been in working order for some time and have been subjected to exhaustive tests by a commission appointed by the Director-General of Spanish Posts and Telegraphs. In March it was reported that the Admiralty had accepted a tender for an important extension of the naval wireless station which is situated on Horsea Island in the upper reaches of Portsmouth Harbor. Originally the aerials were 180 feet high, but they are to be replaced by 400 foot aerials, and the electric installation will also be improved, enabling communication to be established with all parts of the Mediterranean.

In reviewing progress in 1913 we referred to some wireless telegraphy experiments made on moving trains on the Delaware, Lackawanna and Western Railroad. Further tests were made during the past year, tests which demonstrated the efficiency of the Marconi system without a doubt. The railway company has completed a steel tower 402 feet high on the water front at Hoboken and has installed a 5-kilowatt high-frequency set at this point. On September 19th wireless messages were received from Hoboken at the Lackawanna wireless station at Buffalo, a distance of 410 miles on a wave length of 2,250 meters. A regular wireless service will shortly be commenced. The example of the Postmaster-General in deciding to substitute wireless telegraphy for the existing overland wires in exposed parts of the United Kingdom is to be followed by the government of the Commonwealth of Australia, so as to bring outlying country districts into permanent communication with all the towns and business centers. Twelve wireless installations have been established in the country districts of Queensland and New South Wales. The federal government has also decided to employ wireless telegraphy as an aid to the construction of the trans-continental railroad and to assist the operation of trains.

In answer to a question in the House of Commons on May 13th the Postmaster-General made the following interesting announcement: "A successful demonstration of wireless telegraphy at 100 words a minute was recently given by the Marconi Company between Chelmsford and Letterfrack (Galway), and it is proposed to adopt this method of working between a station which I am about to establish near Stonehaven and an existing post-office station near Newcastle-on-Tyne as a stand-by in the case of the interruption of the overhead lines." High-speed transmission and reception is rapidly becoming essential to the efficient working of commercial wireless telegraph stations. By the use of such a system several telegraphists can be employed in punching the tape to feed one transmitter, and thus all messages can be got through without delay and the traffic capacity of a station can be increased many times.

Although Great Britain has hitherto taken no very prominent part in the organization and maintenance of an international time service, there are signs that the subject is beginning to arouse some public attention. Mr. Charles Bathurst asked a number of questions in the House of Commons on April 21st with a view of eliciting information. He pointed out that as a result of the International Conference on wireless time signals which took place in Paris in October, 1912, a preliminary list of high-power wireless stations organized to transmit time signals at stated hours had been issued. Although this list contained stations in every part of the world it contained no station in any part of the British Empire. Mr. Churchill, who replied, admitted the facts were as stated by Mr. Bathurst, "but," he added, "the British delegates at the conference made certain recommendations for the establishment of time signals at wireless stations in the dominions and colonies which would have the effect of greatly increasing the value of the scheme, and I understand that these recommendations have been brought to the notice of the governments concerned." The report of the Astronomer Royal for Scotland refers to the new receiving time-signal apparatus which during the session 1913-14 was added to the equipment of the Edinburgh Observatory.

Considerable attention was paid during the year to the controlling of mechanisms from a distance solely by the aid of electric waves. Several articles dealing with this subject appeared in the *Wireless World*, one of the most interesting being on remote-controlled fog signals installed in the Firth of Clyde. With the opening of a new station at Kingston a new link was formed in the Canadian wireless chain. This station, which was built by the Canadian Marconi Company, is a standard 5.5-kilowatt station. Bombay, like all principal ports in the world, is now fully served with wireless telegraphy equipment to meet present requirements, and this has been demonstrated in the work that has been carried out at the new wireless station on Butcher Island.

The new wireless station at Carnarvon in North Wales, for communication with New Jersey, U.S.A., has now been completed some time and the American station or rather stations—for the system employed is duplex and the transmitting and receiving stations are some distance apart—was also finished during the past year. The plant at the New Jersey stations is practically identical with that at the Welsh stations.

Farmers residing in the isolated districts of Australia have long been handicapped by the lack of means of swift communication with the outside world. Far from towns, they are often compelled to put up with inconvenience and dangerous delay in the satisfying of wants and necessities. An interesting suggestion for a remedy for this state of affairs has been made by Mr. W. King Witt, vice-president of the Wireless Institute of Victoria, who has pointed out that the terrors and disadvantages of loneliness might be greatly reduced by the use of wireless telegraphy.

An important link in the trans-Pacific wireless chain was formed with the opening of the Marconi high-power wireless stations at San Francisco and Honolulu. This is an event of world-wide importance, signaling as it does a further advance in the commercial development of wireless telegraphy by bringing that means of communication within range of a considerably increased number of users of the world's telegraphs, to whom the reduction of cost which the wireless service makes possible, in addition to its other advantages, is a matter of no small moment. According to the latest Australian newspapers, the authorities are making arrangements for big improvements at the different lighthouses around the coasts of Australia and new lighthouses are to be provided where necessary. The question of communication with the shore is also under consideration, and it is reported that in this connection a low-power wireless system will probably come into operation. In the army and in the navy wireless telegraphy now plays an important part and is being used very extensively in the present war. Naturally this brief review only covers some of the most important developments during the past year. Wireless telegraphy advances very rapidly and a complete survey of twelve months' progress would occupy far more space than we can spare.

* *The Engineer.*

A Practical Fertilizer for Wartime in Germany

In the last analysis a man's ability to fight depends on the quality and quantity of his food, and these depend, if his country is blockaded against supplies from elsewhere, on the quality and quantity of the crops that can be raised at home. But of all the factors that determine the latter, that of the proper fertilizer, or plant-food, is the weightiest.

Small wonder, then, that German agriculturists, cut off from the customary supplies of Chili saltpeter, should be considering this question anxiously.

A writer in a recent number of the German journal devoted to the interests of the oxygen and nitrogen industries, *Zeitschrift für Sauer und Stickstoff Industrie*, discusses the question to much purpose. He points out that the chief fertilizers generally employed, besides the potassium salts, are Chili saltpeter and sulphate of ammonia, while the artificial substitutes, nitrate of lime and Norwegian saltpeter, compose only 5 to 10 per cent of them.

Since Germany is herself the chief source of sulphate of ammonia and salts of potash, there can be no lack of these, and they may even fall in price, because of export being pretty well cut off. But the writer has grave doubts as to the possibility of the Haber process being as yet able to put enough ammonia on the market to replace the Chili and Norway saltpeter to such an extent as to prevent the price from soaring. He therefore advises German agriculturists to make every possible use of other sources, and to collect those fertilizers which are readily obtainable in Germany and apply them in time to prevent a reduced harvest next year.

At his instigation Herr Julius Woldering of the *Ritter-gut Jocksdorf* has been conducting practical experiments with a fertilizer composed of finely ground calcium carbonate and coal or pulverized coke, with excellent results. He says:

"An addition of about 20 per cent of fine sifted coal or coke in most cases is a good substitute for Chili saltpeter, and is, at least for a like yield, considerably cheaper than all other mineral chemicals. This fertilizer of lime and pulverized coal has given extraordinary results with rye, oats, potatoes, peas, and beans." He advises that the mixture be used in stables in the winter as an underlay for the straw, in order to absorb the highly valuable nitrogenous fluids. This forms an excellent meadow fertilizer.

A very great advantage of this fertilizer is the fact that the raw materials can be hauled in wagons and mixed by the farmer himself. In localities where large quantities of sulphite lye from cellulose factories can be obtained it makes an admirable addition to the manure, but such addition requires a special method of handling, which the farmer will have trouble in doing for himself. He estimates that the cost of this lime-coal fertilizer is only 5 per cent of that of Chili saltpeter.

The crop yield is, according to the above-mentioned experiments, at least equal to that from the usual mineral fertilizers. He also finds that the crop is sounder than that produced by Chili saltpeter, which forces the growth too much. Another important feature is that the addition of carbon to the soil compensates for the gradual depletion of this element by the steady sale of the greater part of the straw each year. Also a large part of the straw used for bedding can be dispensed with. He closes by urging German agriculturists to profit by this new cheap fertilizer, whose value has been conclusively proved by the scientific researches of Dr. Fischer and Dr. Bornemann.

Encouraging Tree Planting

The Massachusetts Forestry Association is making some very practical and well-directed efforts in the way of interesting towns within the sphere of its activities to undertake the work of tree planting systematically by offering a series of prizes. In four classes of towns, designated on a population basis, which win prizes for excellence in street tree planting the association will plant one hundred additional shade trees, which should be a strong inducement to any community that takes a proper pride in the appearance of its streets. The association is also encouraging town forests, and for the town that takes the first place in this work the association will award a prize in the form of fifty acres of white pine to be planted free of cost by the association. These are good suggestions that might be adopted by associations in other States.

Making Safe Steel Rails

A New Process Intended to Meet Modern Railroad Requirements

An authority on railroad matters has stated that "90 per cent of the rail failures can be divided into two general classes, first, crushed and split heads, and second, broken bases. The former are caused by excessive segregation producing brittleness in the interior of the section and the latter can usually be traced to a seam in the bottom of the base. Fifty per cent of the rail problem consists in getting sound metal of even composition, and 40 per cent consists in so rolling the steel as to avoid seams in the base."

These conditions have, of course, made themselves

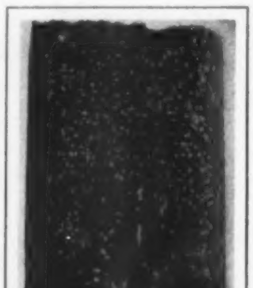


Fig. 1.—Face of an ingot before heating. Fig. 2.—After heating, adhering scale removed.

felt only since the weights that the rails have to sustain have increased to their present proportions, and it is evident that the art of rail making has not kept up with the progress in railroad development in other directions, for the facts show that merely increasing the weight of the rail does not enable it to meet the increasing demands that are being made on it. If proof of this were necessary it could be furnished by the record of one road which had 2,760 rail failures during the three winter months of 1911-12, and the fact that rail failures are rapidly increasing in this country. The conditions and the reasons have been recognized, and attention has been called to the fact that chemical analysis of a test ingot does not furnish assurance of the condition of the finished rail, and that the specifications governing the acceptance of rails are entirely inadequate.

Why this state of affairs should exist is difficult to say, even while recognizing the difficulties that confront the rail maker; but it is gratifying to see that at least one concern is taking active steps in seeking a remedy, as described in the following paper read by Mr. Robert W. Hunt before the American Society of Mechanical Engineers, which is here reproduced from the *Iron Age*, but it may be noted that one of those who discussed this paper made the very direct suggestion that the remedy cured something that ought not to exist.

Increased weight of rolling stock and speed of traffic have necessitated increasing the size of the rail sections, and hence their weight; and as many of the details of rail manufacture have been changed with such alterations, it is not surprising that new and unexpected physical weaknesses developed in the heavier rails. One of the most notable was failure through crescent-shaped pieces breaking out of the rail flanges, followed by at least one, and in many cases several, ruptures across the whole section of the rail. Investigation showed that in practically every instance of such failure there was a more or less pronounced seam running longitudinally in the bottom of the rail near its center, and thus immediately under its web. This seam occurs at the top of the curve of the crescent-shaped break and it is undoubtedly the point at which the fracture starts.

It is true that rails with actual flaws in their flanges have been rejected as first quality ones and that a very pronounced seamy condition of the bottom of the rail would also cause its rejection. Such rejections were the cause of frequent disputes between the mill operatives and the inspectors, the point being as to how far the inspectors were warranted in carrying their condemnation; but, as already said, it was not felt that a single seam, unless very pronounced, would be dangerous.

The crescent-shaped breaks were of such frequent occurrence that they indicated a very serious condition and led rail makers to experiment with the design of their rolling passes with a view to obviating the formation of the bottom seams. It was found that fewer seams were produced by such changes, but they were not entirely eliminated. While more or less successful in preventing the formation of seams through lapping on the bottom of the rails, the formation of seams in other parts of the section was not particularly affected.

T. H. Mathias, assistant general superintendent of the Lackawanna Steel Company, determined that the most certain way of getting rid of seams was to remove that portion of the metal which contained them, and, as applied to steel rails, thus to eliminate them from both the base and head of the rail. This was a reasonable assumption, but its execution, I think, would have seemed very impractical to most metallurgical engineers. Mr. Mathias reasoned that the primary causes of seams existed previous to any rolling of the steel, in fact, were incident to the casting of the molten metal into ingots. He knew that disk-like apertures were formed on the sides of ingots while the molten metal was being cast and were probably caused from air being entrapped against the sides of the ingot molds by the hot steel as it rose in the molds, a condition which was not controlled in regular manufacturing routine. This condition is illustrated by Figs. 1 and 2, which are photographs of the same face of an ingot, Fig. 1 showing the side as it would appear before heating, while Fig. 2 shows it after heating, with the adhering scale removed. Fig. 3 represents the actual size of a section of a face of such an ingot, and gives an illustration of how serious such apertures may be. It will be appreciated that, as the section of the ingot is reduced and elongated in the rolling process, so, of course, will the apertures be stretched longitudinally and thus be formed into seams.

Mr. Mathias demonstrated that there is another constant condition present in the rolling of large steel ingots, in the formation of a decarburized surface on all of their four faces, about 5/16 inches deep, and containing from 8 to 10 points lower carbon than the metal immediately under it, the decarburized envelope undoubtedly being produced through the oxidizing conditions to which ingots are subjected in the soaking pits where they are heated preparatory to rolling. A thick oxide scale is always formed on the surface of ingots in the pits, so that conditions are invariably present for the production of such

Fig. 8.—The milling tool.

a layer of lower carbon metal on their outside faces. Fig. 4 illustrates the presence of this lower carbon envelope or skin. It shows a polished and etched cross-section of a part of an ingot which has been heated to a rolling temperature in the soaking pits but not rolled, from which it will be realized that ingots of large section have both disk-like apertures on their four faces and a decarburized envelope in which they are contained.

Mr. Mathias was convinced that during the process of rolling ingots into rails it was practical to remove mechanically the parts of the enveloping steel which would form the top of the head and bottom of the flange of the rail, and experimented accordingly. He designed and his company installed as an addition to their rail train, a milling, or a hot sawing machine, as I believe Mr. Mathias designates it, to cut off hot metal without retarding the regular operation or thus interfering with the production of the mill. This is illustrated by Fig. 5, which is a photograph of the machine in operation. The machine is located in echelon in relation to the rest of the rail train.

The ingot is reduced in the blooming rolls to an 8 by 8 inch cross-section and after cropping the ends the bloom is further reduced in the roughing or shaping stand of rolls by five passes. When it leaves these rolls, it is approximately 75 per cent finished and at this period it is carried to the right and entered between two pinch rolls with its base or flange side up. A bar which will make four 33-feet rails is at this point in the rolling operation about 60 feet in length; therefore, the area of metal to be cut off or removed in the milling machine is approximately $\frac{1}{8}$ inch deep, 7 inches wide and 60 feet long. It is driven through the pinch rolls at a rate of 60 feet in 30 seconds. The pinch rolls have a draught of about $\frac{3}{8}$ inch and thus force the bar between the two milling saws, which are so arranged in the housing that they may be raised or lowered as desired. From 1/32 to 3/64 inch of metal is milled from the head and base of the bar, the front end of which, immediately on passing from between the rolls, is caught by a second set of pinch rolls which have a draught of about 1/16 inch. These pinch rolls force the bar between the tools, pull it from between them, and also hold it in practically perfect line for the milling operation. The milling apparatus is driven electrically and requires about 600 horse-power for its operation.

Fig. 6 shows an etched cross-section of the piece preparatory to its entering the milling machine, and on it is clearly shown the enveloping layer of lower carbon steel.

As the milled dust or particles of steel are thrown out, they are hit by water under pressure which forces them into a chute and also prevents the material from adhering together. By the chute they are carried below the mill and caught in boxes or receptacles suitable for charging as scrap into the open-hearth furnaces. Fig.

Fig. 5.—Hot sawing or milling machine in operation.

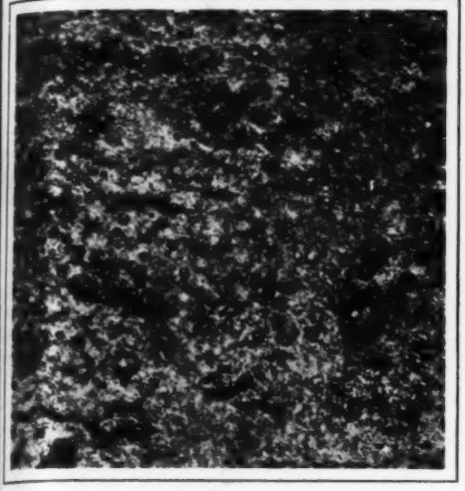


Fig. 3.—Section of face of ingot, full size.

7 shows the condition of the accumulated material which, is in regular open-hearth furnace charging boxes.

Fig. 8 shows one of the milling tools. It is 5 feet in diameter with an 8-inch width of face and revolves at a peripheral speed of 2,500 feet per minute, thus causing an engagement of about 400,000 teeth per minute on the hot rail bar. The teeth are of 0.80 carbon steel, and it has been demonstrated that they will mill at least 30,000 tons of material without requiring dressing. The one shown had milled about 15,000 tons.

Fig. 9 presents the shape of the bar after it leaves the milling machine preparatory to further reduction in the regular rail rolls. It will be noticed that the milling on the flange has not reached the extreme edges of the bar, and on the head side has not affected the corners, and it will be recalled that Fig. 8 showed the milling tool with a straight face. It is apparent that either by a modification of the shape of the piece as presented for treatment in the milling machine or, what will probably be more practical, changing the face of the tool, the milling can be extended to the extreme edge of the flange portion of the bar and somewhat around the corners of the top or head side. This will undoubtedly be perfectly practical and thereby eliminate the seams which may be located in those parts of the bar. Such elimination is not accomplished at present, and perhaps it may not be necessary. The primary object was to eliminate the seams from the central portion of the bottom of the rail which had been the starting point of the moonshaped failures, and to remove them from the top or bearing surface of the head of the rail. Personally I think it will be desirable to extend the milling by the use of concave-faced tools.

The work of rolling which the steel receives after the removal of the more or less laminated metal must produce a better product than if such elimination had not taken place, and, in the case of steel rails, it should not only make them less liable to breakage on account of seams in their flanges, but also enable them better to resist the abrasive effects of traffic.

During the many years of my connection with rail making I have examined a great many etched specimens of rails, not only directly in connection with the process under consideration, but for various other reasons. From such experience I can fully appreciate what Mr. Mathias has accomplished. The surfaces of practically all rails, when etched, will show some seams on both base and head, and very frequently the extent of such defects will not be appreciable if the scale has not been removed. Even then it is not always an easy or certain matter to estimate the depth of the seams. When the rails have been subjected to the Mathias milling operation and still show pronounced seams it has been found that breaking tests will practically always develop the fact that the suspicious marking is an actual seam.

To illustrate the appearance of many ordinary steel rails of commerce when etched, Figs. 10 and 11 show the surfaces of both heads and flanges. These specimens were taken from rails made by several different makers, including the Lackawanna Steel Company. These illustrations not only clearly show the field for such an operation as I have described, but also the extent to which Mr. Mathias has been able to accomplish it.

While I have confined myself to the matter of steel rails, it is patent that the process will be of great value in the preparation of blooms for axles and all other kinds of forgings. As is well known, it is practically the universal custom to endeavor to remove the seams developed in rolling axle billets by chipping them out through the use of pneumatic hammers, and for some of the higher characters of forgings, notably for automobile parts, the endeavor to eliminate the seams is carried to the extent of turning off the whole surface of the billets. I am confident that by the Mathias plan the greater part, if not all, of such work can be superseded.

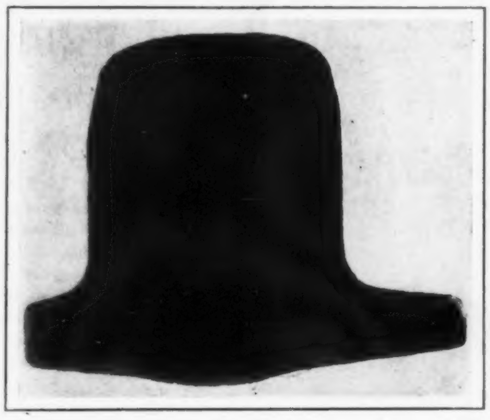


Fig. 6.—Cross-section of bar before entering machine.

Fig. 9.—The bar after it leaves milling machine.

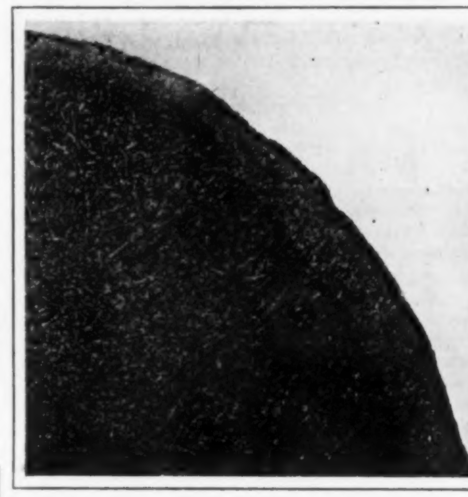


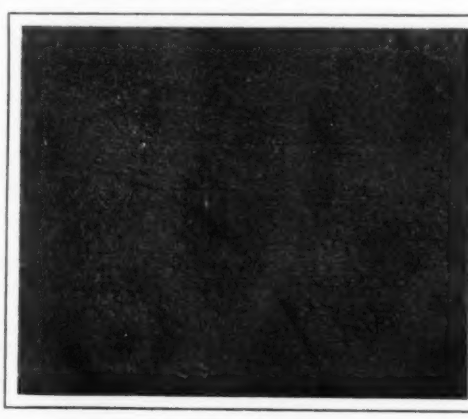
Fig. 4.—Etched surface showing lower carbon skin of ingot.

Top surface.

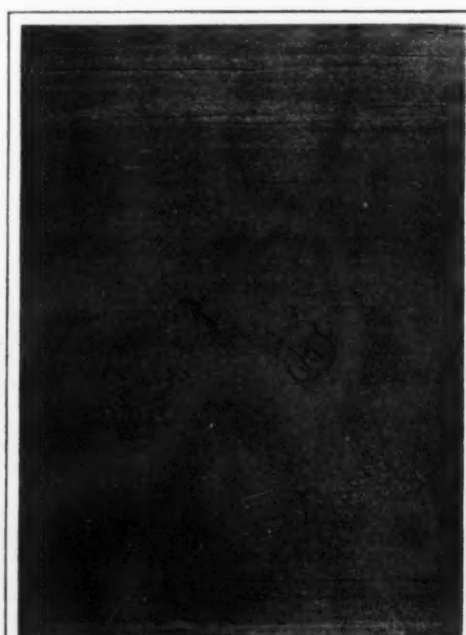
Bottom surface.

Fig. 10.—Untreated rail.

Fig. 7.—Cuttings produced by milling.



Top surface.



Bottom surface.

Fig. 11.—Milled rail.

Waste in Hiring and Discharging Employees*

A Discussion of an Important Industrial Problem

By Magnus W. Alexander

It has pleased your President to style as an "address" what I wish to present to you in an informal way, in reference to an investigation into the economic waste of unnecessarily discharging employees. I have not heretofore spoken publicly on the subject, and have unsuccessfully tried to dodge it at this time, mainly for the reason that, in order to give proper background to the statements which I desire to make, I ought to present corroborating figures and facts, but cannot do so without divulging information given to me confidentially by a number of manufacturing concerns throughout the country. I shall be obliged, therefore, to use as illustrative figures aggregate statistics of several concerns rather than concrete examples of individual employments.

Everyone who is an executive knows how disheartening it is in industrial life to be obliged occasionally to dismiss employees in obedience to business conditions and not at all on account of any fault of such employees. Disregarding the personal and human aspect of the problem, and looking at it solely from the cold business standpoint, it is at once clear that every unnecessary dismissal of an employee means a definite economic loss to the employer. If through the adoption of different methods than are now in vogue, this economic waste can be prevented either in whole or in part, it becomes a duty of the employer to himself and to his employees to re-arrange his methods of employment in accordance with improved standards. Many employers have recognized the truth of this statement, and have found it profitable to maintain specialized employment departments in charge of competent managers. They know from experience that it does not pay to hire and discharge haphazardly; they realize that it costs money to train an employee, even a skilled workman, in the special practices that are peculiar to a given concern, and that the dismissal of an employee, except for good reasons, means that the expenditure for his training has gone for naught and that an additional expense must be incurred in the training of a new employee.

Appreciating the situation, I have given some time and thought to this subject and will present to-day an outline of my findings. I hope, at the same time, to make employers recognize more fully than they have in the past the importance of this phase of economic management.

A great deal has been said in the last few years, and properly so, about reducing the cost of production through so-called "scientific management," which endeavors to eliminate every "unnecessary motion" and every unnecessary expenditure. Hand in hand with, if not even preceding this effort, should go a well-directed endeavor for a closer analysis of the men whom we take into our employ, of the systems under which we train them in our work, and of the reasons for and the methods under which we let them go, only to have their places filled again by new recruits.

My observations were concerned with large, medium size and small manufacturing concerns throughout the United States, all of which form a part of the mechanical industries. During the summer of 1913, while in Europe, I made similar investigations in factories in Austria, Germany, France and England. Information and statistics from these European factories would indicate that the problem under discussion is not only a national but an international one; it is so much the more surprising, therefore, to find that it has received so little serious attention by sagacious business men on this and the other side of the ocean.

The investigation endeavored first to trace the curve of engagements and discharges in the various concerns during the period of one year, and then to secure and study the reasons for the discharges in order to find, if possible, practical remedies for the resulting situation. All data were obtained for the year 1912, which may be considered to have been an industrially normal year.

The investigation covered the employment and discharge of all classes of employees at the various factories except those belonging to the commercial and engineering organization and to the general executive staff. A record of those who had entered the service of the concerns for the first time and of those who had been working in the same place at a previous period was also obtained, for it was assumed that re-employment would usually cause a smaller expense than the employment of entirely new people unfamiliar with the conditions prevailing at a given factory.

*Delivered before the National Machine Tool Builders' Association, New York City.

For the group of factories for which I shall present figures in the aggregate it was found that of all people engaged during the year 1912, about 73 per cent were entirely new employees, and correspondingly about 27 per cent were re-engaged employees. As a general proposition, this percentage will apply fairly well to any normal employement in the mechanical industries.

The group of factories just alluded to, covering the employment of male and female persons and a great variety of mechanical manufacture requiring labor ranging all the way from the highest skilled to entirely unskilled workmen, gave employment to 38,668 employees at the beginning and 46,796 employees at the end of the year 1912. *The increase in the working force, as between January 1st and December 31st, amounted, therefore, to 8,128 people. Yet the records show that during the same period 44,365 people were engaged, indicating that 36,237 people had dropped out of the employment during the year for whatsoever reason.* In other words, about 5½ times as many people had to be engaged during the year as constituted the permanent increase of the force at the end of that period.

Several reasons might be given in explanation of this condition. It might be stated that the labor market in a given locality was in part responsible for the situation; it might be claimed that in a particular plant a temporary piece of work had to be done, such as the digging of a foundation or the building of a structure, for which labor in excess of the normal quota was needed temporarily, to be dispensed with again when the special work was finished. Unusual conditions of employment may be pointed out as the result of a highly fluctuating productive situation, brought about in turn by a largely varying commercial demand on the factory during the four seasons of the year. Finally, sight must not be lost of the fact that some people die, others drop out on account of prolonged sickness, and still others leave the employment for reasons that could not have been obviated by the management.

The important fact, however, stands out that 44,365 people had to be engaged during the year to retain less than 20 per cent of that number.

Theoretically only as many people ought to have been hired as were needed permanently to increase the force. As business men we know, however, that theoretical conditions do not surround our commercial enterprises and that we must make certain allowances in order to view the problem in its practical aspect. Accordingly, we must admit that

(a) Men die and must be replaced;

(b) Men leave on account of sickness for sufficiently long periods that their places must be filled by others;

(c) Men, even though they have been selected for their positions with good judgment, leave of their own accord because they do not find it possible to remain in their new positions, whether on account of climatic conditions, domestic affairs or other reasons necessitating their removal from the locality;

(d) Finally, it must be recognized that no employment department can run on a 100 per cent efficiency basis.

Taking these items into account, it must be clear that more than X people will have to be hired during a year in order to increase the working force by X persons. In an attempt to assign values to the four causes just enumerated, I have assumed that annually

1 per cent of all employees die;

5 per cent leave on account of prolonged sickness;

10 per cent withdraw for reasons that could not have been foreseen at the time of their engagement; and

75 per cent constitute a readily attainable efficiency of an employment department.

These figures find their support in the following considerations:

After ascertaining the average age of employees in the group of factories under investigation, namely 31½ years for male and 23 years for female employees, I turned to insurance statistics and found that 8.5 out of every 1,000 male persons of 31½ years of age and 7.95 out of every 1,000 female persons of an average age of 23, engaged in general factory employment, die annually. The experience of several mutual benefit associations in factories, some extending over a period of almost 10 years, revealed that annually almost 7 in every 1,000 members were removed by death. These statistics, then, fully corroborated my assumption that death removes 1 per cent of factory employees annually.

Insurance statistics also show that about 8 per cent of average factory employees are sick annually for periods of two weeks or more; this percentage drops considerably when sickness of three weeks' duration or more is taken into account. Again, the experience of mutual benefit associations fairly well agrees with the data of insurance companies. Knowing, however, the prevailing custom in most factories to carry on sick leave for much longer periods than two weeks those of whose sickness the management has definite knowledge, I have assumed that 5 per cent of all employees will have to be replaced on account of prolonged sickness and consequent withdrawal from the service.

As to the number of people who withdraw during the year for whatsoever other reason, except that of sickness and death, no reliable experience seems available. In fact, the only information that I could find is that contained in the United States Civil Service report, according to which 8 per cent of all government employees are separated from the service annually for any reason, including that of sickness and discharge. Realizing, however, that governmental employment conditions are different from those in industrial establishments, I have doubled the government estimate by allowing 16 per cent for withdrawal by death, sickness and resignation, or 10 per cent for withdrawal by unavoidable resignations alone.

Finally, I believe that a 75 per cent efficiency of an employment department, and even a greater efficiency, should readily be attainable in a highly specialized department in charge of one or a few persons.

It follows, therefore, that while theoretically 8,128 people should have been employed to allow for an increase of the working force by that number, 11,825 persons should have been engaged in addition, to cover withdrawals by death, sickness and resignation, and to allow for practical employment results. If we take cognizance, furthermore, of normally fluctuating productive conditions necessitating at times more and at times less employees, and of unpreventable exigencies of the labor situation, we could make a further allowance of 2,187 persons, representing 5 per cent of the total working force throughout the year.

While theoretically, therefore, only 8,128 persons should have been engaged, practically the engagement of 22,140 could readily be defended.

What should be said, however, of the fact that in order to increase the force during the year by 8,128, 44,365 total had to be engaged, of whom 22,225 were therefore engaged above the apparently necessary requirements?

It is obvious that a considerable sum of money must have been wasted in engaging and correspondingly discharging unnecessarily so large a force of men and women. In order to secure a lucid picture of this fact, I have tried to assign a dollar-and-cents value to the figures just quoted. No reliable investigation seems to have been made and published in respect to such financial valuation. Industrial managers were, therefore, interviewed in an effort to obtain from them if possible a consensus of opinion. They were rather loath to express their views because they had not given heretofore serious thought to the question. Their estimates ranged from $30.00 to $150.00 per employee; few placed the financial valuation of the waste at less than $50.00 per employee and some went even as high as $200.00 per employee. The great difference in these estimates is no doubt due to the diversity of the industries which the managers represented.

One machine tool builder, who is usually very keen in following up matters of this kind, after they had been called to his attention, looked into the subject with some care and stated it as his belief that the engagement of almost 1,000 persons in his plant during one year while the permanent increase in his force amounted to less than 50, reduced his profits by fully $150,000.00; he therefore estimated the economic waste of the unnecessary engagement of an employee at about $150.00. The head of a large automobile manufacturing concern stated with equal positiveness that the engagement of a new employee would involve an expenditure of at least $100.00. This statement is so much the more surprising as it is well known that on account of the high wages paid in the automobile industry generally, and in the plant referred to in particular, the management should be able to command the best type of labor both as to technical skill and general discipline; and this should materially reduce the cost of training new employees. Still another manager who employs a great deal of female labor estimated this cost in some departments as high as $200.00 per employee.

Unquestionably the skill, experience and intelligence

of a new employee has much bearing upon the amount of money that needs to be expended for his training. Another important consideration is whether the new employee is working on expensive or low priced machinery, or with high or low priced tools, or on expensive or cheap material; and to a certain extent whether or not he has been employed before in the same shop and particularly on the same class of work.

This thought led me to subdivide the employees under investigation into several groups and to study each group as to its requirements for the training of an employee both as to quantity and quality of the instruction. Accordingly, I established the following classes:

Class A, comprising highly skilled mechanics who must have practiced their trade for a number of years in order to attain the required high degree of all-round experience and proficiency;

Class B, comprising mechanics of lesser skill and experience, who likely could acquire an average degree of proficiency within a year or two;

Class C, composed of the large number of operatives, usually known as piece workers, who without any previous skill or experience in the particular work attain efficiency within a few months, depending on the character of the work.

Class D, including all unskilled productive as well as expense laborers who can readily be replaced in the course of a few days; and

Class E, comprising the clerical force in shop and office.

The employees assigned to each class were again subdivided in the ratio of 73 per cent to 27 per cent, to separate those that may be assumed to be entirely new recruits from those who may be considered to have had previous experience in the same factory.

On this basis, the following distribution of the employees was obtained:

In Class	Total Engagements			Unnecessary Engagements		
	All	New	Old	All	New	Old
A	4,881	3,563	1,318	2,445	1,785	660
B	6,519	4,759	1,760	3,266	2,384	882
C	15,087	11,014	4,073	7,558	5,517	2,041
D	14,905	10,881	4,024	7,467	5,451	2,016
E	2,973	2,170	803	1,489	1,087	402
All	44,365	32,387	11,978	22,225	16,224	6,001

The next question is: What factors mainly contribute to the cost of training a new employee?

This cost may be considered to result from:

(*a*) Clerical work of hiring;

(*b*) Instruction of new employees by foremen and assistants;

(*c*) Increased wear and tear and damage of machinery and tools;

(*d*) Reduced rate of production during early period of employment; and

(*e*) Increased amount of spoiled work by new employees.

The expense of the clerical labor of hiring will be small per individual, somewhere in the neighborhood of 50 cents for each employee.

The instruction expense, on the other hand, will vary largely in amount according to the skill and experience of the new employee and the nature of his work. It will be lowest for Class D and highest for Class C employees, for the latter must be instructed most and watched longest. Without now taking the time for a detailed explanation of the conclusions, I feel justified in assigning the following expense values, to wit:

Per Employee

Class A	$ 7.50	Class D	$2.00
Class B	15.00	Class E	7.50
Class C	20.00		

The value of the increased wear and tear and the damage of machinery and tools by new employees is difficult to estimate. It will be little if anything for Class D and E employees, for whom it may be presumed to be $1.00 per employee. It may reach thousands of dollars for damage to expensive machinery in the keeping of Class A, B, and C employees for whom an amount of $10.00 each would be very reasonable.

The loss due to reduced production is entirely dependent upon the value of the produced article and the experience and skill required for its production. On the basis of some investigation as to how soon employees in the various classes are able to reach normal productive efficiency in a factory new to them, and with due regard to prevailing average wages, I have assumed the loss to be:

Per Employee

Class A	$15.00	Class D	$ 5.00
Class B	18.00	Class E	20.00
Class C	20.00		

Similarly, for the expense of spoiled work, which varies with the value of the raw material and the labor expended on it, I have assigned $15.00 for each Class A, B and C employee, and practically nothing for Class D and E employees.

The respective totals of these items show that the cost of training new employees amounts to the following:

Per Employee

Class A	$48.00	Class D	$ 8.50
Class B	58.50	Class E	29.00
Class C	65.50		

Bearing in mind the assumption that about 27 per cent of newly engaged employees had worked before in the same factory, the cost of their new training should be considerably reduced, even though this reduction would seem justified only if the employee were put back on exactly the same class of work upon which he was previously engaged. A conservative estimate would place the expense of breaking in re-hired employees at $10.00 in Class A, $20.00 in Class B, $35.00 in Class C, $5.00 in Class D and $10.00 in Class E for each such employee.

Out of these considerations grows the astonishing conclusion that the apparently unnecessary engagement of 22,225 employees within one year, in the group of factories under investigation, involved an economic loss of $774,139.00.

This means that the cost of training a new employee, taking all in all, amounted to $34.85 or about $35.00, which not only comes within the range of estimates heretofore mentioned, but brings the figure practically near the lower limit of the estimates.

This important question immediately arises: How can this unnecessary loss of about three-quarters of a million dollars be avoided in future, if not entirely, at least in part?

Five answers present themselves readily:

1. An adequate study of current employment statistics and a careful analysis of the reasons for the discharge of employees will furnish a fact basis of great value;
2. High-grade men must be placed in charge of the hiring departments of concerns;
3. The exercise of proper methods for the taking care of new employees is an exceedingly important problem;
4. Effective systems of apprenticeship and specialized training courses must be maintained; and
5. Commercial requirements should be so regulated as to secure a fairly uniform productive situation throughout the year.

It should be unnecessary to point out that the reasons for the voluntary or involuntary leaving of an employee as given by the foremen on the discharge cards cannot be fully relied upon, and that special effort should be made to get at the real reason for an employee's discharge so as to secure a correct basis on which to build remedial action.

In the light of the above statements and figures it should also be unnecessary to defend the necessity for the highest grade of judgment in the hiring and discharging of employees. The employment "clerk" of to-day will have to be replaced by the employment "superintendent" or "manager" of to-morrow, not merely by changing the title of the man but by changing the type and character of the man even though this will mean a higher salary. Second in importance to the manager of the plant should be the assistant who is entrusted with the duty of bringing into the plant the men and women that are needed from time to time, and of keeping them there, contented and efficient. What methods to employ to take care of employees from the very moment when they start in their new work is a far more important question and presents a far more difficult problem than that of the proper selection of new employees from among the applicants for the job. The very best thought on the psychological side of industrial management will have to be applied to this particular phase.

It has been recognized for some years, even though not perhaps as fully as should be, that it is the duty of industrial managers so to take hold of the youth of the land and properly train the boys and girls who wish to or by circumstances may be obliged to choose a vocational occupation for their livelihood, that they may become intelligent, skillful and contented workers and leaders in our constantly growing industrial army. Although to a certain extent all managers take an interest in this problem of providing an adequate supply of properly trained workers, many have not yet discovered that it will be essentially worth while to set aside the required time from their busy life and to devote appropriate effort and financial support to this issue.

As for the last suggested remedy to bring about a more evenly arranged production throughout the year, I can only express the belief that much good to all concerned can be accomplished in this respect, and I am encouraged in this feeling by the growing examples of standardization of product which brings with them ability to manufacture for stock as well as for immediate delivery, thereby permitting the maintenance of a fairly even production throughout the year.

Along the five lines of remedy herein suggested lies, to my mind, the solution of a problem which looms large before our eyes and will loom larger as competition will grow keener. The "Man" problem as contrasted with the "Material and Machine" problems will and must in future engage more fully and more keenly our best attention.

It is somewhat reassuring at the present time, although it may not remain so for long, to know that the conditions of employment herewith presented do not seem to be any better in European industrial countries. Merely in support of this statement, the following illustrations, drawn from factory experience in Germany and England, may be of interest:

Factory	Employees at Beginning of Year	Employees at End of Year	Total Increase During the Year	No. Persons Hired
1	13,556	16,450	2,894	9,530
2	10,998	11,914	916	17,059
3	9,165	12,032	2,867	10,982
4	3,158	3,149	Minus 9	2,148
5	365	470	105	637

In presenting to you the results of my investigation into the waste of hiring and discharging employees, I have made no effort to paint a black picture but have merely presented the varied colors of the industrial spectrum. I have pictured what seems to be an average condition throughout the country. Time has not permitted to place before you a detailed analysis of the contributing causes and remedial actions for the problem under discussion; however, "a word to the wise is sufficient."

I now close with an earnest plea that you give the problem careful consideration and indulge in similar investigations in your own factories to assure yourself of the state of your affairs and, where necessary, to correct unsatisfactory conditions. It will also give you a more concrete knowledge of the subject, so that a future discussion of it may be conducted with a more assured hopefulness of finding and applying the right remedy or remedies for an unsatisfactory situation. Through a correct solution of the problem we shall not only contribute materially to the welfare and prosperity of the industries, but also to the contentment and well-being of the thousands and thousands of employees who cannot be benefited in any degree by short-time and haphazard employment.

In view of certain legislative and administrative tendencies now affecting American industries, it is important also to reflect that constant fluctuation in the working force of an establishment must materially increase the difficulty of maintaining among the employees loyalty to the management, *esprit de corps* and general contentment. Just as little as we shall be able to take quicksand and knead it in our hands into a solid lump, so also will we find it impossible to take hold of an ever-changing mass of employees and transform it into a homogeneous, intelligent, contented body; furthermore, this condition will nullify to a large degree the beneficial effect of many well-intentioned efforts of the management, such as sickness and accident insurance plans, pension systems and other phases of industrial betterment work.

And last but not least, *the problem of employment offers an opportunity for constructive work in which employers and employees can readily be brought together for mutual benefit*, for no right-thinking man, whatever his position, can justly object to any well-directed plan which will give employees continuous work throughout the year and will enable employers to maintain steady production.

Properties of Selenium

An extremely interesting report of an investigation of the crystal forms of metallic selenium by Mr. F. C. Brown recently appeared in the *Physical Review*. In this research a large number of new crystals of metallic selenium were formed, some of very large size. All of these forms, except one, are very transparent selectively to light, a large amount of light penetrating to a greater depth than 0.2 millimeter. All the crystal forms increase in conductivity when illuminated, and with but one exception they have been observed to be doubly refracting. The action of light is in the selenium itself and not at the contacts. Mechanical pressure produces a genuine change in the selenium, which may alter the conductivity more than a thousand times. The absolute change of conductivity in one crystal by constant illumination was proportional to the conductivity in the dark, when that conductivity was altered by pressures between 1 atmosphere and 180 atmospheres. The temperature at which the crystals sublimate in mass influences the character of the wave-length sensibility curves. The production of individual crystals of metallic selenium of large size opens up a wide field of investigation which promises to be free from some of the possible complexities in selenium cells.

The common method of navigation of small streams by the native Panamanians is by means of the *cayuca* or dugout, which varies in length from eight to thirty-five feet, and is cut from a single tree. These boats are used by the natives for bringing fruit and produce to market, and it is a common sight to see them loaded with sugar cane cut in sections eight or ten feet in length.

The low entrance to limestone cave on the Chilibrillo River opens into a series of long corridors and chambers more or less intercommunicating.

Waterfront of Panama City, where the boats come in to market, in the early morning, loaded with fruit and vegetables from the neighboring islands.

Flashlight of small cluster of bats before alarmed.

Clusters are ordinarily formed of a great number of individuals, probably several hundred in some instances. The variety shown is one of the largest of South American bats, one specimen secured having a wing expanse of twenty-six inches. The bats are strong and muscular and always ready to bite. The masses of bats bear close resemblance in form the stalactites with which the walls and domed ceilings are covered.

Newly flooded [...]

Rivers in the Gatun region have risen, as this ph[...] of the r[...] one, has now an extent of one hundred and sixty-f[...] in places[...] In the photograph an iguana can be seen on th[...] egret on [...]

In a bat cave.

Showing method of photographing bats by flashlight. As the flashlight powder used is exceedingly explosive the expression of apprehension on the face of the operator is not to be wondered at.

Flashlight photograph of one of several varieties of opossums encountered in the Canal Zone.

The particular opossum shown is the commonest species and by reason of its abundance and its omnivorous appetite, it proved a serious obstacle to flashlight photography. Probably seventy-five per cent of the flashes fired were sprung by opossums who found and fired the camera shortly after dusk before better game was moving.

Views in the Panama Canal Zone Secured by the Expedition Inv[...]

...ly flooded ...d.
...as this ph... ...e of the region, previously a negligible
...nd sixty-fo... ...h in places of seventy to eighty feet.
...seen on th... ...te egret on the log at the center.

...ack howler, the largest of the Panamanian monkeys, ...ed upon by the natives as a weather prophet, its ...long and reverberating howl being most frequently ...just preceding a heavy rain.

Flashlight photograph of bats.

...t these caves were inhabited by several different species of bats, it was found that, for some reason not clearly ..., each species isolated itself in a particular grotto. ...y this, but the different sexes of each species was ...milarly separated and isolated.

Flashlight picture of paca (Agouti paca virgata), one of the largest of the existing rodents, the closely related carybara alone exceeding it in size.

The paca is an animal of nocturnal habits and, therefore, can be photographed only by means of flashlight apparatus set at night. Note in the animal's mouth the mango which was used as bait. This is one of the game animals of the natives who call it *conejo pintado* or spotted "rabbit."

It was because of the flooding of the Gatun Lake basin by the huge dam at the Gatun locks, thus causing abrupt changes in the faunal conditions, that an expedition under the patronage of Mr. George Shiras, 3rd, was undertaken. The houseboat formed the base camp from which trips were made by launch or small boat, sometimes along rivers which heretofore have been inaccessible owing to shallow water. The houseboat had sides of cheese cloth and copper screen to keep out mosquitoes.

Scene on the Rio Chilibrillo up which trips were made to visit the bat caves.

As palms never grow in water, something of the extent of the flooding of this region can be judged.

Lake end of Gatun locks looking out over Gatun Lake.

Three different stages in filling the locks are shown, the lock at the left being empty, the one in the lower right-hand corner half full and the one in the upper right hand corner full. E...rgency dams are seen in the background. Four locomotives similar to the one shown ... to be used for each ship, two being in front and two in the rear.

...h Inve... New Faunal Conditions Since the Gatum Lake Was Created

New Faunal Conditions in the Canal Zone*

Notes of an Expedition to Investigate the Results of the Physical Changes in this Region

By H. E. Anthony

DURING the months of February and March of last year it was the good fortune of the author to accompany, as an American Museum representative, Mr. George Shiras, 3rd, on a trip to the Canal Zone. Mr. Shiras desired to obtain photographs by flashlight of the animal life of that region, a method of which he is one of the foremost exponents to-day and which has yielded him some remarkable results in temperate regions. It was through his generosity that the Museum was able to send a collector to Panama with him.

It was expected that faunal conditions in the Canal Zone would be undergoing abrupt changes because of the damming of Gatún Lake and the consequent extensive high water. From a basin with no lake worthy the name, with standing water confined largely to marshy areas except during the height of the rainy season, the Gatún region has been transformed by the huge dam at the locks into a lake of one hundred and sixty-four square miles in extent and a depth of seventy to eighty feet in many places. This flooding of ground formerly high and dry, it was anticipated, would drive many animals to seek new homes or might even threaten some of the more restricted, lowland-living animals with extermination. Incidentally many of the islands and ridge crests left above water might have a concentrated fauna driven there from the adjacent flooded localities. Other phases of the question dealing with the newly created lake were the wiping out of the lowland forests by submergence, the rise of new aquatic flora, such as the water hyacinth, and the probable inhabitation of the lake by water birds. Such were some of the items in the purpose of the expedition and we were equipped to take advantage of these new conditions if the foregoing assumptions proved correct.

As Gatún Lake was the center of investigation, it was planned to work from a house boat as a base camp, with a launch and small boats for side trips. Accordingly a boathouse was made over by a few alterations, but only after considerable time had been spent in trying to secure something available for the purpose. The house boat was so low in the water that she could be towed only in a calm sea, a condition of the lake only rarely met with, and at best the launch could make but slow time pulling her. Late afternoon of March 6th saw us leaving Gatún with the house boat and by 3 o'clock the next morning we were tied up at the head of a waterway or *trocha* that branched off from the Rio Trinidad. This was our main camp and we hoped to be able to work the undisturbed jungle from here. Unfortunately, a plantation nearby, a young fruit district only recently made accessible by high water, chose this time to burn over some clearings, and we found that the smoke materially interfered with our success. Cameras with flashlights and bait were set out in promising spots, lines of traps for mammals were run daily, while the jungle was hunted in hopes of shooting specimens.

It was at this spot that we made the acquaintance of the largest of the Panamanian monkeys, the "black howlers." Frequently their queer booming, roaring howl echoed through the jungle, a call that carries for long distances. They howl oftenest just before or during a rainstorm and the natives thus look upon them as weather prophets. Upon one occasion I stood almost under some trees through which a troop was passing, while the first big preliminary drops of a sudden shower pattered upon the leaves about me. The volume of sound that issued from the black shaggy throats was so great and so suggestive of a large animal, a lion for example, that I found it hard to reconcile myself to the actual facts. I felt a pang of regret at silencing one of the "howlers," but as a specimen was needed I shot one of the foremost and heard him crash through the limbs to the ground. Pangs of a more effective sort were experienced when my native boy and I attempted to retrieve the monkey, for he had fallen underneath a bees' nest the size of a bushel basket and we found the nest too late to avoid it.

Other interesting mammals encountered here were the pretty squirrel-like marmoset, the short-haired anteater and several species of opossum, while we were continually wondering at the variety of the bird life and the diversity of the bird songs and callnotes. The noisy parrots that shouted in the morning until the jungle rang with their tumult, the grotesque toucans which at times vied with the parrots, the calling of the parrakeets, and the peculiar chorus-like calls of the chachalaca, or "wild turkey," produced an impression that must ever be associated with jungle memories. At night mysterious noises were heard from unknown sources, and one weird laughing call in particular caused conjecture to run rife, there being as many opinions as there were listeners.

Besides the work done on the Rio Trinidad, several long trips were made by launch far up the river as the launch could ascend and two others up the Rio Chilibrillo to some limestone caves for bats. On these trips it was found that the rising waters had ascended far up the river valleys, which in this part of the region have very little fall, making them navigable to launches where formerly it would have been impossible to take a *cayuca* or native dugout. Some of these flooded rivers—rivers by courtesy, for in the States these streams would be called creeks—with their banks densely lined by jungle vegetation which met overhead and dropped long vines and streamers into the waters, were very beautiful.

Everywhere we found the forest inundated. In regions early flooded, where the trees were submerged for the greater part of their height, all the trees were dead and leafless with an occasional great clump of orchids, the only green left. Many square miles of the surface of Gatún Lake are thickly studded with dead tree-tops of what was at one time splendid tropical forest. In regions of later high water many of the trees were still green and blossoming; especially was this so along the shores where but the lower part of the tree trunks were under water. It is not improbable that some of the more resistant trees may live to a ripe old age with their roots some feet below the surface of Gatún Lake, for some species were found flourishing among their long since dead companions. No new aquatic growth, arisen to take advantage of the altered conditions, was noted, but the conditions had probably not been in operation long enough to bring about such a growth. The dead trees are constantly falling and the far-reaching crash of their descent is one of the common sounds of the lake.

Gatún Lake will undoubtedly produce new economic conditions among the natives of the adjacent district. These natives formerly had no other waterways but the few rivers that traversed the interior basin, and were available for navigation only to a limited number of villages. Such rivers were the Chagres, Trinidad, and Gatún. Now the far-extending lake shores provide such an accessible waterway that the natives are learning to navigate on lake waters, and every morning their *cayucas* may be seen lined up at the native market along the lock-front at Gatún. Being primarily river boatmen, however, they are yet somewhat distrustful of the lake winds and do most of their traveling at night when the winds die down. During the dry season, from January to April, the winds blow across the lake toward a northern quarter of the compass, and just the reverse holds true for the rest of the year. This wind at times becomes strong enough to threaten small boats seriously, and at practically all times of the day would be a strong check on the progress of the native dugout that was facing it. We found it necessary to move the house boat always at night and in the early morning hours because of this wind, and this proved a serious obstacle to working many localities, because it was out of the question to run at night without a moon, and when we most wished to move we had a late rising moon. After driving the launch full-tilt over a floating tree and into partially submerged bush and tree tops, trying to steer by lantern light, we confined our future movements to moonlit hours.

Whenever one left the waters of Gatún Lake the dense, unaltered jungle was at once encountered and no matter how much its beauty was to be admired from the boat, its impenetrability was no less to be deplored. It was useless to attempt to leave the trail without recourse to the *machete*, the long brush knife of Latin America, and many were the varieties of briars and thorns to be avoided. Once into the thick growth of the jungle, the hunter found it necessary to stand minutes in one spot in order to look into all the arboreal nooks and crannies, so many were the possibilities, so many the great orchid-covered limbs and wide branching trees, and so loath to move the denizens of the jungle. The orchids and epiphytic air plants were very abundant and became so heavy a burden at times as to break down the limb or even the entire tree that harbored them, and not infrequently I witnessed the downfall of some tree overburdened in this manner; once indeed, warned by a premonitory cracking, I was forced to move with considerable speed to escape a flying limb.

Mosquitoes, the former bane of early Canal days, were found but sparingly. Even outside the district of government patrol we were bothered but little by them, although we were told that later, during the rainy season, they were much worse. A few spots were encountered where mosquitoes were bothersome, thus arguing a local distribution. The ticks and red bugs, however, made up in diligence for any slights we might feel we had suffered from not being met by mosquitoes. The jungle everywhere seemed to harbor these pests and they did all they could to make life miserable for us. Ants also were found in abundance and it was fortunate indeed that our camp was a floating one and thus cut off from inroads of these nuisances. One species of ant in particular will be long remembered by two members of the party, for it stung with a venomous vigor never equalled by any bee and made the victim imagine he had been struck by a snake at least.

Concentration of animal life had taken place at the rising of Gatún Lake, and most of the islands formed had many inhabitants at first. The Gatún Hunt Club, however, soon reduced the population of these islands by hunting them with hounds, and as the quarry in most instances could not leave the island, the result was a clean sweep of all the larger species. We were too late, consequently, to find abundant game on any of the islands near Gatún. I accompanied this hunt club on one occasion, securing two peccaries.

The most efficient method of hunting the Panamanian jungle was by means of a headlight at night. The rays of the light, worn on the hunter's head, are reflected by the eyes of the animal, which shine like two orbs of fire—red, green, or bluish, depending on the animal "shone." The hunted animal will see nothing but the approaching light and falls an easy victim to the rifle or shotgun. On account of the danger to domestic stock and to people by promiscuous shooting at night, this method has been prohibited on the Zone, but beyond Zone limits it is to-day the favorite mode.

The trip resulted in a good series of flashlight photographs of opossums and some of the smaller mammals. The apparatus for "flashing" the animals was set out by some runway or water-course where animals were apt to pass, and consisted of a mechanism to fire a magnesium flash and at the same time trip the shutter of the camera, which was fastened in a manner to command the trail. A thread attached to a bait and stretched out before the camera fired the flash when the animal pulled it.

Series of the rodents and the smaller mammals were secured for the Museum collections and for the most part are of species not hitherto represented. The time was too limited to secure many of the larger mammals which are found in the Zone.

* The expedition worked under authority from the Canal Commission. It is of note that Colonel Goethals, as the first civil governor of the Canal Zone, continues adherence to the policy he maintained during the engineering work in the region, namely, that the Isthmus shall be a game preserve. Exception to the observance of the laws against shooting game outside a short open season will be made only in favor of such occasional zoological expeditions. Reprinted by permission from the *American Museum Journal*. Illustrations by courtesy of Mr. George Shiras, 3rd, who organized the expedition and made the flashlight photographs; and also of the author, who photographed the general scenes.

Electric Power for Agriculture

THE idea of applying electric power to agricultural operations is attracting attention, especially in view of the great hydro-electric plants that are being developed in districts remote from present manufacturing activities, where the power must be transmitted great distances. If some of this power could be utilized locally it would be a good thing for both the producer of electricity and the user, as it would enable a higher continuous steady load to be carried on the generators, and this in turn would enable the power to be sold at a lower rate, as more power would be produced without increasing the overhead expenses. One obvious application of electricity in some districts would be for running irrigating pumps, and this could be done economically if enough power was taken to pay for the installation of the lines. There is considerable machinery on every farm that requires power to operate and which could utilize electric power to advantage if the cost was right, and the introduction of power for pumping plants would lead the way to making this kind of power for farm machinery generally. If an irrigating plant can be so arranged that it can serve several different tracts of land a steady load is furnished the can be supplied cheaply by the power station.

Protection Against Torpedoes*

A Discussion of the New Conditions Created by Mines and Submarines

ALTHOUGH the cause of the sinking of the "Formidable" in the Channel on New Year's Day is not known to the public with any certainty, it is generally assumed that either a torpedo or a mine was responsible. If a torpedo was really the cause, then the highest praise is due to the German submarine which fired it. The weather was extremely rough at the time and the difficulties to be encountered were enormous; so great, indeed, that we are almost prepared to regard them as insuperable. If, on the other hand, we accept the alternative, we are faced with the problem how a German mine got so far west. We say a "German mine," because there is some reason for believing that the Germans are not careful to ensure that their fixed mines go automatically out of action, as ours do, when they break adrift from their moorings, and they alone use the barbarous free floating un-timed mine. Probably the Admiralty is in a position to say which of these two causes, both of which have elements of improbability, was really responsible, and we are not likely to know for a long time to come. In the meanwhile the problem of the resistance of ships to submarine attack has been raised by this latest loss.

The subject is one that has attracted a great deal of attention in recent years; but, on account of the new policy pursued by the Admiralties of most countries and of our own particularly, very little is known outside a limited circle, as to what steps have been taken to guard against this ever-increasing danger. As we shall show presently, it is probable that no country fully appreciated the submarine menace when the war began. Until a few years ago there was never any question of armoring ships' bottoms. It was thought that a moving ship could generally maneuver out of the way of a torpedo when it was conscious of the direction from which it came, as, for example, in the case of an attack from a destroyer. Protection then was only needed when the vessel was at rest, and for this purpose the torpedo net was given to all ships of any size. The net, however, is no longer an infallible defence against modern torpedoes, and since the development of the submarine, with its invisible attack, the stationary or slow moving ship is at a great disadvantage. A new method of defence is needed. The problem is one of extreme difficulty. There are only two lines on which a solution is to be sought if complete immunity is to be found. Either the bottom plating of the vessel must be made so powerful that the explosion of a torpedo against it can cause little damage, or means must be discovered for keeping the torpedo at a distance. In harbor it is not very difficult to ensure the latter. Obstacles may be placed to guard the entrance and, as a secondary precaution, the nets may be lowered on the ships themselves. In the open sea such protection is impossible, and the only course is to depend upon speed, maneuvering qualities, and gun fire. By these means the submarine may be driven off or avoided, and it is also conceivable that in certain states of the sea, when its approach is made visible by its wake, the torpedo might be sunk or exploded by gun fire with suitable projectiles. Generally speaking, however, recourse to such means is out of the question, and safety lies only in the discovery and destruction or avoidance of the attacking vessel. Where the latter is a submarine and the water is broken the difficulty is great, and the best defence remains irregular speed on an irregular course. We are thus left with the fact that no mechanical means have yet been discovered to prevent a well-aimed torpedo striking its mark with, in the case of older ships at least, fatal effect. The only hope, then, lies in so constructiong the bottoms of ships that the submarine explosion shall do no or only localized injury. It is on this line that architects are working.

Whether or not the bottoms of our latest ships are armored we cannot say; but even if they are not, which is probably the case, a form of subdivision similar to that employed in recent French ships—the "Bretagne" class for example—is used. In general terms this consists in forming a long internal caisson or cofferdam inside the vessel at the vulnerable under-water parts. It forms in fact a kind of double skinning, only that the space between the outer and inner skin is greater than in passenger vessels and the inner skin is made thick and of a particularly tough kind of steel. Occasionally a flexible diaphragm is placed midway between the two skins, and helps to protect the inner one against injury. The force of the explosion of a mine or torpedo expends itself in destroying the outer skin and is unable to damage seriously the inner. The ship is, of course, badly injured, but not sunk. We know that this plan has been adopted in British vessels, for Mr. T. G. Owens has stated that "in most of the later ships there are submerged longitudinal protective bulkheads to ward against the effect of submarine explosions, either from torpedoes of mines" (Inst. N.A.), and we have good grounds for hoping that any of the latest battleships and battle-cruisers would not suffer the fate of the old vessels that have been sent to the bottom by the invisible attacks of the enemy; but we may ask how long after such an explosion would the damaged vessels again be available for service. "Sub-division," said Sir John Biles at Newcastle last July, "naturally suggests itself as one means of minimizing the effect of this damage; but, when all that is possible in this direction has been done, there seems to be no great certainty that a battleship will still be a formidable fighting machine after having received the successful contact explosion of a 21-inch torpedo." He then asked, "Can we do anything in addition to sub-division to preserve the ship for effective fighting purposes?" and replied, "The effective advent of the submarine seems to justify a serious consideration of the question of applying armor to the bottoms of ships." Sir John then showed that if the bottom was to be armored with 4-inch plates, which he suggested would be needed, a reduction in speed of two knots or a diminution of above-water armor would be necessary.

Speaking on this paper, Sir Philip Watts made one or two remarks that give us some insight into the course adopted by the Admiralty. He said: "Defence can be provided by fitting deep inner bottom spaces backed with tough protective plating, by which the loss of buoyancy resulting from a hit may be considerably restricted," and "Up to the present time the submarine menace has not been considered of sufficient importance to justify the adoption of armor for protecting the bottom; although discussed from time to time it has never been fitted." Sir Philip Watts and many others may now see reason to alter their views, but it must be remembered that with a single possible exception, about which little or nothing is known save from American sources, no modern big British ship has suffered from mines or torpedoes. Only elderly ships have been sunk, ships that were built when submarines were little considered. On the other hand, it appears that the "Viribus Unitis" was torpedoed recently by the French, and it is reported that a modern French ship of the "Courbet" type (1910) has also been struck, but in neither case has the vessel sunk. There is a rumor also that the "Goeben" has just been torpedoed without sinking. The reason in these three instances may be that in not one did the torpedo reach a fatal spot, but equally it may be that the new form of construction does, at least, save the life of the ship.

It will be gathered from this brief review of the position that while armored bottoms have been discussed, they have not been adopted, but that practically all recent ships are provided with under-water chambers or caissons, on which the explosion of mines or torpedoes can expend themselves, and are in other ways subdivided. The only other protection against submarine attack is the mobility of the vessel herself and the use of nets. Sub-division does not protect a vessel from injury of such a nature that she would have to spend many weeks in dock after a successful attack, and hence it cannot be regarded as final. We are thus driven to the conclusion either that armoring of bottoms must become a general practice or that some entirely new means of repelling or nullifying attack must be found. Here is a problem upon which our readers might exercise their ingenuity. It is, we admit, not very promising, but we suggest as a course which does hold out some hope of success that in the first place means for discovering the position of an unseen submarine might be sought. To know the position of your enemy is to win half the battle, and if we could discover some device which would lend sub-marine eyes to the battleship as the aeroplane has lent super-terranean sight to the general staff, we should be on a long way to avoiding such calamities as have occurred. It is well known that all submarines are noisy and that in a submerged condition they are driven by powerful electrical machinery. We suggest that two lines of research are opened by these facts. A modification of the submarine bell aparatus now fitted to many merchant ships might be used to discover the direction in which a submarine lay, or some delicate device which would discover its position by magnetic means might be invented. The matter, of course, bristles with difficulties, which are increased by the fact that the information on which invention must be based cannot be obtained; yet the more minds are directed to the problem the nearer shall we be to a solution.

* *The Engineer.*

On the Temperature of the Mercury Arc*

By J. C. McLennan, University of Toronto

IN the course of some experiments recently carried out by the writer on the fluorescence of iodine vapor under stimulation by the light from the mercury arc, it became necessary to know the temperature to which the iodine vapor was submitted during the exposures. As there appeared to be no information available on the temperatures obtainable from such types of mercury arcs as those used in the fluorescence experiments mentioned, a few sets of observations were made and an account of these is given in the following note.

Geiger[1] who had studied the temperatures in electrical discharges in hydrogen, nitrogen and atmospheric air at low pressures in Geissler tubes provided with Wehnelt cathodes has shown that with currents of about an ampere passing in the tubes temperatures beyond 1,000 deg. Cent. have been observed with thermocouples directly exposed to the discharge.

These high temperatures were also found to characterize the discharge in the mercury arc when a thermocouple was exposed directly to the luminous vapor. To bring out this point measurements were made on the discharge in a tube that had a platinum-iridium thermo-couple sealed into it with one junction situated at the axis of the tube. The terminals were joined—one to a standard Siemens and Halske potentiometer, and the other cooled to 0 deg. Cent. by melting ice—and this gave the electromotive forces of the junction when discharges of different intensities were sent through the tube.

In making the observations the tube was joined to the 110-volt direct current supply circuit with a variable resistance in series which enabled one at will to modify the strength of the current in the arc.

Before sealing the wires into the tube the thermocouple was calibrated by exposing the junction to a series of temperatures given by (1) melting ice, (2) water and naphthalene boiling at atmospheric pressure and (3) zinc, coin silver, and potassium sulphate at their respective melting points.

In making observations the fall of potential between the two terminals of the tube was measured simultaneously with the strength of the current passing through it. At the same time the corresponding electromotive forces were read off from the compensation apparatus.

A temperature of 1,400 deg. Cent. was reached when a current of 10.6 amperes was passing through the tube and it was deduced by supposing that the calibration curve was rectilinear beyond 1,070 deg. Cent., the highest point of calibration. Platinum, platinum-iridium thermo-couples are not generally used in measuring temperatures higher than 1,100 deg. Cent., or at most 1,200 deg. Cent., but in the present case it was found that the couple still remained intact when an electromotive force of 196 x 10^{-4} volts was reached and this was taken from the curve as representing approximately 1,400 deg. Cent.

It is quite clear that with a platinum platinum-rhodium thermo-couple still higher temperatures might have been recorded, but after the maximum current of 10.6 amperes had been running for a short time the tube cracked and the investigation was not carried further.

The investigation shows that with a moderate consumption of energy the luminous vapor in the mercury arc may attain and easily exceed a temperature of 1,400 deg. Cent.

The investigation suggests, too, that in all probability the temperatures indicated by a thermo-couple when exposed directly to the discharge are still very much below that corresponding to the mean molecular kinetic energy of the luminous vapor. The most satisfactory way, though a difficult one, to ascertain the temperature, would be to investigate the form and variation in width of a selected spectral line when the consumption of energy in the arc is varied.

* From a paper read before the Royal Society of Canada, and published in its *Transactions*.

[1] Geiger, Inaug. Dissert., Erlanger, July, 1906.

Edward Weston's Inventions

Revolutionizing Discoveries that Resulted from Exact Observation and Original Chemical Theories

By Dr. L. H. Baekeland

The pioneer work of Dr. Edward Weston is not easy to describe in a few words. His restless inventive activity has been spread over so many subjects, has intertwined so many interlocking problems, that in order to understand its full value, it would be necessary to enter into the intimate study of the various obstacles which opposed themselves to the development of several leading industries which he helped to create: the electro-deposition of metals, the electrolytic refining of copper, the construction of electric generators and motors, the development of electric illumination by arc- and by incandescent-light, and the manufacture of electrical measuring instruments. An impressive list of subjects, but in every one of these branches of industry, Weston was a leader, and it was only after he had shown the way in an unmistakable manner, that the art was able to make further progress and develop to its present day magnitude.

But why was Weston able to overcome difficulties which seemed almost unsurmountable to his predecessors and co-workers in the art?

The answer is simple: He introduced in most of his physical problems a chemical point of view—a chemical point of view of his own; a point of view which was not satisfied with general statements, but which went to the bottom of things. He did not get his chemistry wholesale as it is dispensed in some of our hot-bed-method-educational institutions. He had to get at his facts piecemeal, one by one, adjust them, ponder over them,—collect his facts with much effort and discrimination; he did not acquire his knowledge merely to pass examinations, but to use it for accumulating further knowledge.

It seems rather fortunate for him that one of the first employments he got in New York was with a chemical concern which made photographic chemicals. This was the time of the wet-plate, when photographers made their own collodion, their own silver bath, their own paper. Whoever went through those delicate operations knew the difficulties, the uncertainties which were caused by small variations in the composition of chemicals or in the way of using them. Photochemistry is excellent experience for any young chemist who is disposed to generalize too much all chemical reactions by mere chemical equations. Whoever has to deal with those delicate chemical phenomena, which occur in the photographic image, knows that many unforeseen facts can not easily be accounted for by our self-satisfying but often superficial generalizations of the text-books.

Weston's tendency to observe small details in chemical or physical phenomena led him to improve the art of nickel-plating and electrolytic deposition of metals to a point where it entered a new era. When he undertook the study of the difficulties in this art, he took nothing for granted, but by close observation he succeeded in devising methods not only of improving the physical texture of the deposit, but for increasing enormously the speed and regularity with which the operations could be carried out; all these improvements are now embodied in the art of electro-typing, nickel-, gold-, and silver-plating.

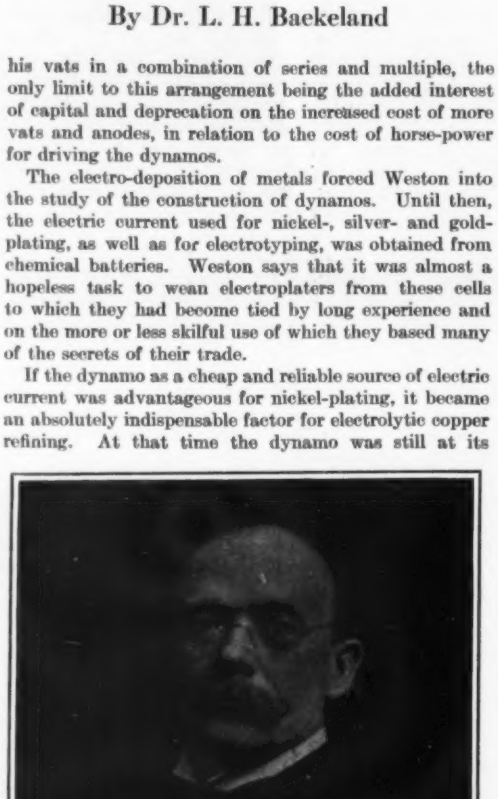
At this time, attempts had already been made for the commercial refining of copper by means of the electric current. But this subject was then in its first clumsy period, far removed from the importance it has attained now among modern American industries. Here again Weston brought order and method, where chaos reigned. His careful laboratory observations, harnessed by his keen reasoning intellect, established the true principles on which economic, industrial, electrolytic-copper-refining could be carried out. Prof. James Douglass (Commencement address, Colorado School of Mines—*Metallurgical and Chemical Engineering*, Vol. XI, No. 7, July, 1913, page 377) referred to this fact in a recent address:

"I suppose I may claim the merit of making in this country the first electrolytic copper by the ton, but the merit is really due him (Weston) who in this and innumerable other instances, has concealed his interested work for his favorite science and pursuits under a thick veil of modesty and generosity."

The whole problem of electrolytic refining, when Weston took it up, was hampered by many wrong conceptions. One of them was that a given horse-power could only deposit a maximum weight of copper, regardless of cathode- or anode-surface. This fallacious opinion was considered almost an axiom until Weston showed clearly the way of increasing the amount of copper deposited per electrical horse-power, by increasing the number and size of vats and their electrodes, connecting his vats in a combination of series and multiple, the only limit to this arrangement being the added interest of capital and deprecation on the increased cost of more vats and anodes, in relation to the cost of horse-power for driving the dynamos.

The electro-deposition of metals forced Weston into the study of the construction of dynamos. Until then, the electric current used for nickel-, silver- and gold-plating, as well as for electrotyping, was obtained from chemical batteries. Weston says that it was almost a hopeless task to wean electroplaters from these cells to which they had become tied by long experience and on the more or less skilful use of which they based many of the secrets of their trade.

If the dynamo as a cheap and reliable source of electric current was advantageous for nickel-plating, it became an absolutely indispensable factor for electrolytic copper refining. At that time the dynamo was still at its very beginning,—some sort of an electrical curiosity. It had been invented many years before by a Norwegian, Soren Hyjorth, who filed his first British patent as far back as 1855. Similar machines had been built both in Europe and America, but little or no improvement was made until Weston, in his own thorough way, undertook the careful study of the various factors relating to dynamo efficiency.



In 1876 Weston filed his first United States patent on rational dynamo construction, which was soon followed by many others, and before long, he had inaugurated such profound ameliorations in the design of dynamos, that he increased their efficiency in the most astonishing manner. Heretofore the dynamos which had been constructed showed an efficiency not reaching over 15 to 40 per cent, gross electrical efficiency, but the new dynamos constructed after Weston's principles, increased this to the unexpected efficiency of 95 per cent, and a commercial efficiency of 85 to 90 per cent. He thus marked an epoch in physical science by constructing the first industrial machine which was able to change one form of energy, motion, into another, electricity, with a hitherto unparalleled small loss. As the improvements in dynamos depend almost exclusively on physical considerations, and have little relation with the field of chemistry, I shall dispense with going further into this matter. But I should be permitted to point out that the first practical application of electrical power transmission for factory purposes in this country, was first utilized in Weston's factory; the success of this installation induced the Clark Thread Works, also located in Newark, N. J., to adopt this method of power transmission for some special work; a method which now has become so universal. For this purpose, Weston had to invent new devices for starting, and for controlling, as well as for preventing injuries to motors by overload.

In Weston's factory also the electric arc was used for the first time in the United States for general illumination.

In fact, from 1875 to 1886, Weston was very energetically engaged with the development of both systems of arc- and incandescent-illumination by electricity. We see him start the manufacture of arc-light-carbons according to methods invented by him, and thus he became the founder of another new industry in America. He continued this branch of manufacture until 1884, at which epoch this part of the business was transferred to another company, which has made a specialty of this class of products, and has developed it into a very important industry. Here again Weston introduced chemical methods and chemical points of view. Among the many objections which the public had against the electrical arc, was the bluish color of its light. Women especially complained that the blue-violet light did not bring out their complexion to the best advantage. Weston first tried to use shorter arcs which gave a whiter light, but this was only a partial remedy. He soon found a more radical and more complete cure by the introduction of vapors of metals or metallic salts or oxide in the arc itself, so as to modify at will the color of the light, and thus he became the inventor of the so-called "flaming arc." It is noteworthy that it took about 20 years before electricians and illuminating engineers became so convinced of the advantages of the flaming arc, that it had to be "re-invented" during these late years, and now it is considered the most efficient system of arc-illumination.

In relation to this invention, it is interesting to quote the following extract of the specifications from his United States Patent No. 210,380, filed November 4th, 1878:

"This rod or stick may be made of various materials—as, for example, of so-called 'lime glass,' or of compounds of infusible earths and metallic salts, silicates, double silicates, mixtures of the silicates with other salts of metals, fluorides, double fluorides, mixtures of the double fluorides, fusible oxides, or combinations of the fusible oxides with the silicates—the requirements, so far as the material is concerned, being that it shall be capable of volatilization when placed on the outer side of the electrode to which it is attached, and that its vapor shall be of greater conductivity than the vapor or particles of carbon disengaged from the carbon electrodes. The foreign material added to the carbon may be incorporated into the electrode by being mixed with the carbon of which the electrode is composed, or it may be introduced into a tubular carbon; but I have found it best to place it in a groove formed longitudinally in the side of the electrode, as shown."

In his endeavor to make the electric incandescent lamp an economic possibility, we see him introduce over and over again, chemical methods and chemical considerations. He first tried to utilize platinum and iridium, and their alloys, which he fused in a specially constructed electric furnace, devised by him, antedating the furnace described by Siemens. This is probably the first electrical furnace, if you will except the furnace which Hare used in his laboratory in Philadelphia.

But these platinum metals showed serious defects aside from their high cost, and by that time Weston had become so familiar with the properties of good carbon that like other inventors, he became convinced that the ultimate success lay in that direction.

And now we see him join in that race of rivalry among inventors who all engaged their efforts in search of the real practical incandescent lamp. Among this group of men, the names of Edison here in the United States and that of Swan in England, have been best known. To go into the details of this struggle for improvement is entirely outside of the scope of this short review.

Edison succeeded in making incandescent lamp filaments by carbonizing selected strips of bamboo. But even a carbon made of this unusually compact and uniform material was far from being sufficiently regular and homogeneous. Indeed, all the then known forms of carbon conductors had the fatal defect of a structural lack of homogeneity. On account of this, the resistance varied at certain sections of the filament, and at these very spots, the temperature rose to such an extent that it caused rapid destruction of the filament; this is somewhat similar to the chain which is just as strong as its weakest link.

These irregularities in the filament reduced enormously the term of service of any incandescent lamp. Weston tried to solve this difficulty by means of his chemical knowledge. He remembered, that, as a boy,

when he went to visit the gas works to obtain some hard carbon for his Bunsen cell, this carbon was collected from those parts of the gas retort which had been the hottest, and where the hydro-carbon gas had undergone dissociation leaving a dense deposit of coherent carbon.

In this chemical phenomenon of dissociation at high temperatures he perceived a chemical means for "self-curing" any weak spots in the filament of his lamp. The remedy was as ingenious as simple.* In preparing his filament, he passed the current through it while the filament was placed in an atmosphere of hydrocarbon gas, so that in every spot where the temperature rose highest on account of greater resistance, brought about by the irregular structure of the material, the hydrocarbon gas was dissociated and carbon was deposited automatically until the defect was cured, with the result that the filament acquired the same electric resistance over its whole length. But this invention, however brilliant, did not limit his efforts. He had become imbued with the idea that the ideal filament would be an absolutely structureless, homogeneous filament, with exactly the same composition and the same section throughout its whole length. He reasoned that such a filament could not be obtained from any natural products, ducts, neither from paper nor bamboo, but that it had to be produced artificially in the laboratory from an absolutely uniform, structureless chemical substance. After various unsuccessful attempts, he finally secured this result by applying his old knowledge of the days when he used to make collodion. He produced a homogeneous, structureless transparent film of nitrocellulose by evaporating a solution of this material in suitable solvents. As he could not carbonize this film on account of the well-known explosive properties of so-called "guncotton," he obviated this difficulty by eliminating the nitrate group of the molecule of cellulose-nitrate by means of ammonium-sulphydrate. This gave him a flexible, transparent sheet, very similar in appearance to gelatine; this material he called "Tamidine." Such films could be cut automatically with utmost exactitude, producing filaments of uniform section, which then could be submitted to carbonization, before fastening them to the inside of the glass bulb of the incandescent lamp.

It is interesting to note here that the modern Tungsten lamp, in all its perfection, made of ductile tungsten, is after all, the fullest development of the principle of an entirely structureless homogeneous chemical filament. The tungsten-filament can stand much higher temperatures than carbon and this property gives it higher lighting efficiency, but the former tungsten filaments of a few years ago, which had a granular structure, had the same defect as the earlier carbon lamps, namely, a non-homogeneous texture and correspondent short life.

While Weston was wrestling with all his electrical problems, and more particularly with the construction of dynamos and motors, he was handicapped continuously by the clumsy and time-consuming method of electrical measurements which were the best existing at that period. Up till then, these methods had been found good enough for physical laboratories, where the lack of accuracy did not result disastrously in hitting the pocket of the manufacturer, or where time—abundant time for observations and calculations was always available. But progress in the electrical industries lagged behind the delay and uncertainties caused by electrical measurements. So Weston was compelled to invent for his own use a set of practical electrical measuring instruments. It was not long before some of his friends wanted very badly duplicates of his instruments; before he knew it, he was giving considerable attention to the construction and further development of these instruments. Just about this time, the electric light and dynamo construction enterprise entered into a new period, where they began to develop in large unwieldy commercial organizations, requiring public franchises and which had to be backed by vast amounts of new capital. In its boards of directors, business men, or financial men and corporation lawyers, became paramount factors and eclipsed in importance the technical or scientific men, who, in earlier days, had almost exclusively contributed to the development of the art.

Following his natural inclinations, Weston soon abandoned his former business connections in order to entrench himself in a field where individuality, science and technology were of almost unique importance, and which he could develop without the necessity of incurring financial obligations beyond what he could master personally. Thus he dropped his connections with the electric light and dynamo enterprises, and we see him now, heart and soul, in another new industry which he created—the art of making accurate, trustworthy and easy to use electrical measuring instruments.

In his factory in Newark, N. J., Weston seems to have instilled some of his own reliability and accuracy in the minds of the men and women he employs.

In fact, has it occurred to you that even a man with the widest knowledge and the highest intelligence, who is not scrupulously reliable and careful, who is not the soul of honesty personified, could not make honest and trustworthy measuring instruments nor create reliable measuring methods?

What Stas did in chemistry for atomic weights, Weston did for electrical measuring; he created radically new methods of measurement, and introduced an accuracy undreamt of heretofore. Do not forget that his problems were not easy ones. When the British government offered a prize of $100,000 for the nearest perfect chronometer, the problem of a reliable chronometer involved considerably less difficulties and fewer disturbing factors than any of those encountered in devising and making electrical measuring instruments. But here again, even at the risk of monotonous repeating, I want to impress you with the fact that the success of the methods of Weston was found in almost every case in the application of chemical means by which he tried to solve his difficulties.

When he took up this subject, the scientists, as far back as 1884, accepted implicitly the belief that the definition of a metal and a non-metal residue lay in a physical distinction; that for metals the electrical resistance increased with temperature, while for non-metals, their resistance decreased with temperature. This was another one of those readily accepted axioms which nobody dared to refute or contest because they were repeated in respectable text-books. And yet, this unfortunate behavior of metals was the greatest drawback in the construction of accurate measuring instruments. Indeed, on account of the so-called temperature co-efficient, all measurements had to be corrected by calculation to the temperature at which the observation was made. This seems easy enough, but it was time consuming and often it is more difficult to make rapid accurate observations of the temperature of the instrument itself. First of all, the thermometers are not accurate, and have to be corrected periodically, and furthermore, it is not an easy matter to determine rapidly the temperature of a coil or an instrument. Moreover, by the very passage of the electric current, fluctuating changes in temperature are liable to occur, which would make the observations totally incorrect. All this led to hesitation and slowness in measurements. Weston wanted to correct this defect, but he was told that the very laws of physics were against his attempts. Before he was through with his work, he had to correct some of our conceptions of the laws of physics; now let us see how he did it:

Weston knew that the favorite metal for resistances was so-called German-silver. Strange to say, he was the first one to point out to the Germans themselves that "German-silver" is a word which covers a multitude of sins, and that the composition of German-silver varies considerably according to its source of supply. The result was that he soon proposed a standard copper- and nickel- and zinc-alloy containing about 30 per cent of nickel, and which had a resistance of almost twice that of ordinary German-silver and a much lower temperature co-efficient. Not satisfied with this, he took up the systematic study of a large number of alloys. The first batch which he undertook to study amounted to more than 300 different alloys. Since that time, he has considerably increased this number, and is still busy at it. Everyone of these alloys he made himself in his laboratory, starting from pure materials, and controlling the whole operation from the making of the alloy to the drawing of wires of determined size. By long and repeated observations, on which many years have been consumed, he was able to determine the electrical behavior of each one of these alloys at different temperatures. After awhile, he began to observe remarkable properties in some manganese alloys he compounded. He managed to produce an alloy which had 65 times the resistance of copper. But getting bolder and bolder, he strove to obtain an alloy which had no temperature co-efficient whatever. He not only succeeded in doing this, but finally produced several alloys which had a *negative* temperature co-efficient. In other terms, their resistance, instead of increasing with rise of temperature, decreased with increasing temperature. He also showed that the resistance of these alloys depended not only on their composition, but on certain treatments which they undergo, for instance, preliminary heating. And since that day, the physicists have had to bury their favorite definition of metals and non-metals. The present generation can hardly realize what this discovery meant at that time. I could not better illustrate this than by reminding you of the fact that in 1892, at the meeting of the British Association for the Advancement of Science, where it was urged to found an institution similar to the Deutsche Reichsanstalt, Lord Kelvin said in his speech:

"The grand success of the Physikalishe-Reichsanstalt may be judged to some extent here by the record put before us by Prof. von Helmholtz. Such a proved success may be followed by a country like England with very great profit indeed. One thing Prof. von Helmholtz did not mention was the discovery by the Anstalt of a metal whose temperature co-efficient with respect to electrical resistance is practically nil; that is to say a metal whose electrical resistance does not change with temperature. This is just the thing we have been waiting for for 20 or 30 years. It is of the greatest importance in scientific experiments, and also in connection with the measuring instruments of practical electric lighting, to have a metal whose electrical resistance does not vary with temperature; and after what has been done, what is now wanted is to find a metal of good quality and substance whose resistance shall diminish as temperature is increased. We want something to produce the opposite effect to that with which we are familiar. The resistance of carbon diminishes as temperature increases; but its behavior is not very constant. Until within the last year or so nothing definite was known of metals from the fact that elevation of temperature had the effect of increasing resistance. The Physikalische Anstalt had not been in existence two years before this valuable metal was discovered."

Then followed this colloquy:

Prof. Von Hemholtz. "The discovery of a metal whose resistance diminished with temperature was made by an American engineer."

Prof. Ayrton. "By an Englishman—Weston."

Lord Kelvin. "That serves but to intensify the position I wished to take, whether the discovery was made by an Anglo-American, an American Englishman, or an Englishman in America. It is not gratifying to national pride to know that these discoveries were not made in this country."

The misinformation of Kelvin was due to the fact that after the Weston patents had been published, his alloy was called *manganin* in Germany, and much publicity had been given to its properties with scant reference to its real inventor, an occurrence which, unfortunately, is not infrequent not only among commercial interests but in technical or scientific circles as well.

No less important was the invention of the Weston cell, which, in 1908, by the international commission for the establishment of standards of electrical measurements, has become the accepted universal practical standard for electro-motive force. Here again, this physical standard was obtained by chemical means.

Until Weston's researches on standard cells, the Clark cell had been the standby of the electricians and electrochemists of the world, as the standard of electro-motive force. It required the keen analysis of a Weston to ascertain all the defects of this cell and to indicate the cause of them. Later, he drew from his careful chemical observations the means to construct a cell which was free from the defects of its predecessors—a cell that had no temperature co-efficient and had no "lag."

He detected that the choice of a saturated solution of sulphate of zinc in which was suspended an excess of crystals of this salt, was an unsuitable electrolyte and one of the principal causes why the indications of the Clark cell varied considerably with the temperature. It is true that this could be obviated by placing the cell in a bath of constant temperature. But this involves new difficulties due to the proper determination of the real temperature. Furthermore, there is always a "lag" in the indications due to the fact that at varying temperatures, it requires a certain time before the solution of the salt has adjusted itself to the co-efficient of saturation for each newly acquired temperature. By studying the comparative behavior of various salts at different temperatures, he came to the conclusion that cadmium-sulphate is more appropriate and this was one of the several important improvements he introduced in the construction of a new standard of electro-motive force.

Dr. Weston assures me that he has succeeded in making his alloys to show only a change of one-millionth for a variation of 1 deg. Cent. The metallic alloys he discovered are used practically in nearly all kinds of electrical measuring instruments throughout the world. Weston instruments and Weston methods are now found in all properly equipped laboratories and electro-chemical establishments of the world. On a recent trip to Japan, I saw them in the University of Tokio, as well as in the Japanese war museum, where their battered remains attested that the Russians used them on their captured battleships. I have worked in several laboratories in Europe equipped with instruments said to be "just as good" as those of Weston, but in most instances they were imitations of Weston instruments and it was significant that they kept at least one Weston instrument to be used to correct and compare their national product.

Long Reinforced Concrete Bridges

Reinforced concrete is so rapidly coming into general use that some figures relating to bridges of considerable size of this construction are of unusual interest. According to recent statements the Walnut Lane Bridge, at Philadelphia, has a span of 233 feet; at Grafton, New Zealand, there is a bridge with a span of 320 feet; over the Tiber, at Rome, 328 feet; at Largweiz, Switzerland, 330 feet; and the proposed bridge over Spuyten Duyvil Creek, New York, 703 feet.

The Gas from Blast Furnaces—II*

Its Cleaning and Utilization

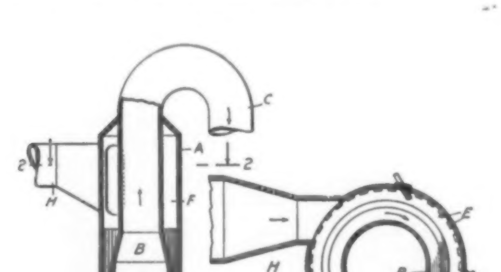
By J. E. Johnson, Jr.

Continued from Scientific American Supplement No. 2040, Page 95, February 6, 1915

With this introduction I cannot do better than quote extensively from Mr. Forbes's paper as follows:

DUST CONTENT IN GAS.

The gas leaving the usual dust-catcher contains an average of from 3 to 4 grains of dust per cubic foot, and its further cleaning is accomplished in one or two principal stages, depending on the ultimate use of the gas; namely, primary cleaning and final cleaning. In primary cleaning, the gas is sufficiently cleaned for economical use in heating hot-blast stoves and for raising steam in boilers; it has been found that the best results are obtained when the dust content of the gas, after cleaning, does not exceed 0.2 grain per cubic foot. In final cleaning, the gas is sufficiently cleaned for use in gas engines, and in this case the best practice has resulted when the dust content of the gas, after cleaning, does not exceed 0.008 grain per cubic foot.



Figs. 5 and 6.—Vertical and horizontal sections of Brassert-Witting whirler.

Various systems and methods are employed for accomplishing the desired results. In modern practice, the gas leaving the blast furnace is, in practically all cases, conducted through down-comer mains and then through a dust-catcher of large capacity, and in some cases through two such dust-catchers in series. A considerable proportion of the heavier dust is deposited at this stage. From the dust-catcher the gas passes to the additional cleaning apparatus through gas mains, usually equipped with downtakes and valves for the removal of the deposited dust. The mode of treatment from this point on varies considerably, according to the opinions of the operators as to the respective merits of various systems.

PRIMARY DRY CLEANING.

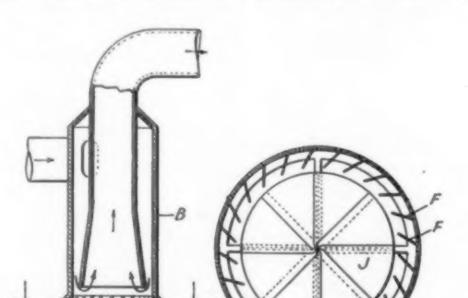
For primary cleaning, a separation of the dust without the use of water—in other words, dry cleaning—has been in favor at many plants on account of the ability to thus conserve the sensible heat of the gas, which is lost when water is used. The fact, however, should not be lost sight of that the benefit derived from the sensible heat of the dry-cleaned gas is largely discounted by the amount of water vapor in the gas. This is especially the case with gas from blast furnaces operating with a high top temperature and using ores and coke containing much moisture existing either free or chemically combined; the water vapor affects the efficiency of the combustion of the gas.

An additional benefit of dry cleaning lies in the greater facility to recover and handle the flue dust in the dry state than in the form of mud or slime in the wet cleaning processes. As before stated, the basic principles in practically all of these dry-cleaning systems depends upon a change in the direction of the gas, a reduction in its velocity, and the separation of the dust by gravity and centrifugal force. The various modifications by which this separation of dust is accomplished are all evolved from the so-called cyclone processes developed in Germany about 20 years ago. Some of these systems recently developed in the United States are the Brassert-Witting, the Roberts, the Kennedy, and the Dyblie. A description of the Brassert-Witting whirler and of the Dyblie whirler will illustrate the general principles of this type of cleaner.

BRASSERT-WITTING WHIRLER.

As shown in Figs. 5 and 6, the Brassert-Witting whirler consists of a vertical outer cylindrical casing, A, and an inner inverted tube, B, which at its upper ends is intergral with the gas main C, which takes the cleaned gas away from the apparatus. This inverted tube is flared at its lower end, D; a number of iron or steel bars, E, are fastened vertically around the chamber F and extend from a point well above the lower edge of the flared end D of the pipe to a point well below the lower edge of this pipe. In the lower part of the chamber F is placed a cone, G, which allows the separated dust to enter the outlet pipe.

The gas enters the apparatus tangentially through



Figs. 7 and 8.—Vertical and horizontal sections of Brassert modification of Brassert-Witting whirler.

the flue H and is given a rotary whirling motion through the annular space between the pipe B and the wall of the chamber A. On coming in contact with the bars E the dust is caught in the channels between these bars and is held in position by the combined action of centrifugal force and friction. As the gas continues to rotate within the annular spaces above mentioned, its velocity is gradually increased by the action of the flared end of the receiving pipe until, when it reaches the lower edge of the end, its velocity is at a maximum. On passing below this edge, the velocity is constantly decreased, the direction of the gas is changed and it passes upwardly through the flared end of the pipe to the outgoing gas main C.

The dust which has been caught in the channels between the baffle bars drops vertically into the bottom of the chamber, past the cone G and into the outlet pipe, whence it is removed as desired.

BRASSERT MODIFICATIONS OF BRASSERT-WITTING WHIRLER.

In the Brassert modifications of the Brassert-Witting whirler, a sketch of which is shown in Fig. 7, the lower portion of E of the casing is larger in diameter than the upper portion B and is provided with a series of inwardly projecting baffle plates, F. The lower portion G of the casing E is cone-shaped and constitutes the dust-receiving chamber. In the bottom of this chamber is a cone, H, whose function is to direct the dust toward the periphery of the dust outlet pipe. Within the chamber I another cone, J, is located and this cone is provided with a series of baffles, which are arranged as shown in Fig. 8.

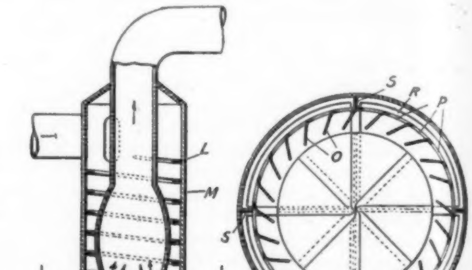
In Fig. 9, which is a further modification, a spiral, L, is provided for the purpose of directing the flow of the gas. The lower end of the outlet pipe is made barrel-shaped. The outer casing M in its lower portion N is supplied with the baffles O, which, instead of being mounted on the casing are bent inwardly therefrom, thus forming the apertures P (Fig. 10). The section N of the casing is inclosed by an outer casing, Q, thus forming the annular chamber R, in which partitions S are placed to prevent whirling of the gas.

The gas is introduced and discharged and the dust is separated in a similar manner to that mentioned in the description of the Brassert-Witting whirler.

DYBLIE WHIRLER.

In this whirler, as in most of these types, the separation is accomplished by combined centrifugal force and the action of gravity. One of the principal features in this particular whirler is the arrangement in the spiral separator of the entrance and exit openings in substantially the same horizontal plane, obviating the necessity of the gas changing its direction of flow at a sharp angle.

Described in general terms, this separator consists of a spiral conduit, the lower open edges of which connect with the dust-collecting chamber. The gas is introduced tangentially and follows a spiral course toward the central axis of the apparatus, the spiral conduit being increased in area before the gas enters the central

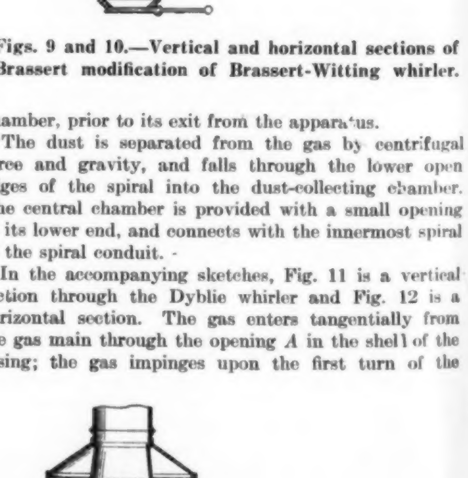


Figs. 9 and 10.—Vertical and horizontal sections of Brassert modification of Brassert-Witting whirler.

chamber, prior to its exit from the apparatus.

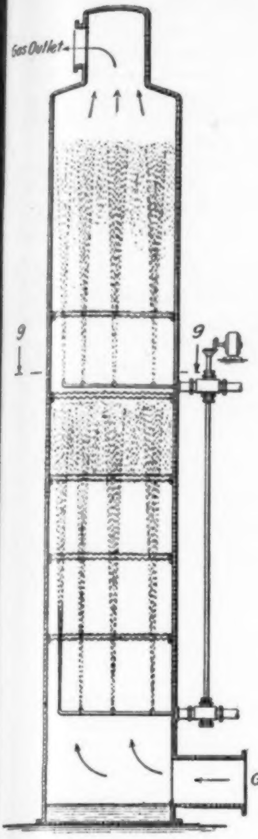
The dust is separated from the gas by centrifugal force and gravity, and falls through the lower open edges of the spiral into the dust-collecting chamber. The central chamber is provided with a small opening at its lower end, and connects with the innermost spiral of the spiral conduit.

In the accompanying sketches, Fig. 11 is a vertical section through the Dyblie whirler and Fig. 12 is a horizontal section. The gas enters tangentially from the gas main through the opening A in the shell of the casing; the gas impinges upon the first turn of the



Figs. 11 and 12.—Dyblie whirler.

* Reproduced from *Metallurgical and Chemical Engineering.*



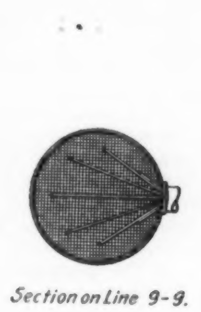
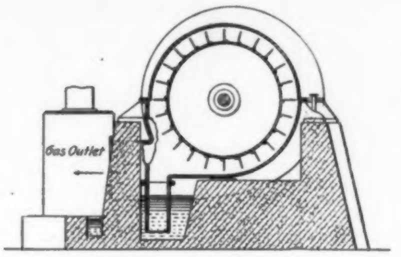
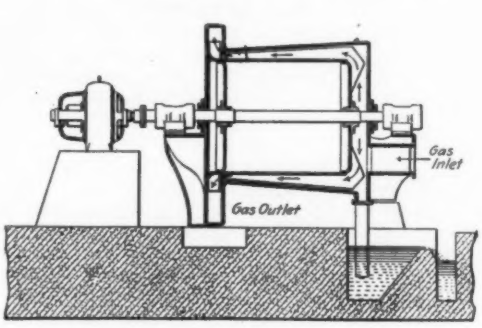
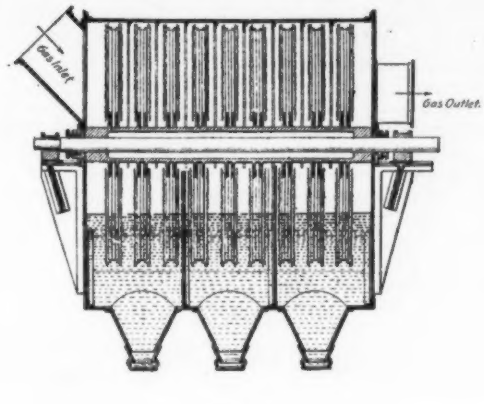


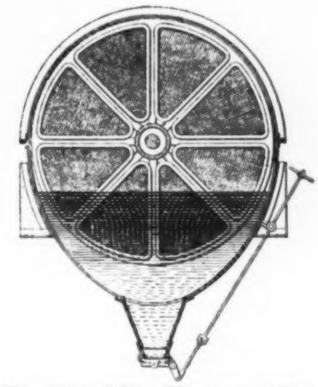
Fig. 13.—Duquesne spray tower.





Figs. 16 and 17.—Theisen gas washer.





Figs. 14 and 15.—Bian gas washer.

spiral *B* and follows the turns of the spiral. A separation of dust from the gas occurs through centrifugal force, the particles of greatest specific gravity being thrown outwardly and falling by gravity to the bottom of the casing. At the point C, an increased area is provided between the spiral and the central chamber, which causes a decrease in the velocity of the gas, thus allowing a further separation.

The inlet *A* and the outlet *D* are in substantially the same horizontal plane, and this permits the separated material to drop out of the whirling gas and prevents its being caught up in the vortex, which happens when a sudden change in the direction of the flow of the gas occurs.

A deflector, *E*, located at one edge of the opening, is provided. This is in the shape of a hook, which acts to catch any dust which might be carried into the casing, and this completes the separating operation.

REMARKS ON EFFICIENCY OF DRY CLEANING.

It has been demonstrated in practice that dry cleaning by anyone of the systems so far referred to, cannot be depended upon by itself to continuously clean the gas from blast furnaces using much fine ore, to the degree desired for use in stoves and under boilers, the amount of dust remaining in the gas ranging from 1 to 3 grains per cubic foot, depending on the working of the blast furnace. Such systems have a value, however, in removing, by simple apparatus and at practically no operating expense, a certain proportion of the dust, and so decreasing the duty upon any apparatus installed for further cleaning.

The above remarks on dry cleaning refer in no way to the Halberger-Beth system, recently developed in Germany, which will be treated separately later on.

PRIMARY WET CLEANING.

For primary cleaning, in Europe in particular, a separation of the dust by the use of water has been preferred for many years to a dry separation, on account of the very much greater efficiency obtained in cleaning, and on account of the importance of reducing the water vapor contents of the gas to a minimum, thus allowing more efficient combustion. The cooling and washing of the gas are usually performed simultaneously, sufficient water being used to reduce the temperature of the outgoing gases to practically the temperature of the incoming wash water. Experience has shown that cooling the gas in this manner, to allow condensation and separation of the water vapor, causes less attendant loss of heating efficiency than prevails in heating with vapor-laden gas.

ZSCHOCKE SYSTEM.

Zschocke washers have been used almost entirely in Germany for wet primary cleaning. These consist of cylindrical or square steel towers fitted with a series of wooden grids or hurdles placed at suitable intervals within the apparatus. These hurdles are arranged in such a manner that the water, which is sprayed in at the top of the tower, is broken up into very fine streams, which drip down between the grids and meet the gas coming up, the gas being introduced at the bottom of the tower. The intimate contact so obtained wets down the dust, which is carried with the water to the bottom. These Zschocke towers are usually water-sealed and cone-shaped at the bottom, and the latest type has a siphon arrangement; in either case, the dust is readily removed from the bottom of the apparatus.

Zschocke towers have been found sufficient to cool and clean the gas to the proper degree for use in hot-blast stoves, under boilers, and for similar purposes. A fan washer, into which water is introduced, is frequently used as an auxiliary to the Zschocke towers for primary cleaning, especially when the scrubbing capacity of the towers is small.

A water separator, equipped with internal baffles, is usually located beyond the washer to allow separation of the entrained water.

Zschocke washers are used considerably in the United States, and some additional systems have also been developed here for the wet separation of dust; for instance, the Duquesne spray tower and the Steinbart spray tower. The basic principle of these spray towers consists of the creation of a rain or spray by means of suitably arranged nozzles, and the gas is cleaned and cooled in passing through this spray.

DUQUESNE SPRAY TOWER.

The Duquesne tower consists of a shell about 80 feet high by 12 feet in diameter. As shown in Fig. 13, the tower contains five sets of double screens, the sets being spaced 6 feet 10 inches apart. Under the first set of screens are distributed seven nozzles, the feed water for which is controlled by a valve outside the tower. Under the fifth set of screens, seven similar nozzles, also controlled by a valve outside the tower, are distributed, just above the range of the lower nozzles.

The controlling valves have a revolving core which

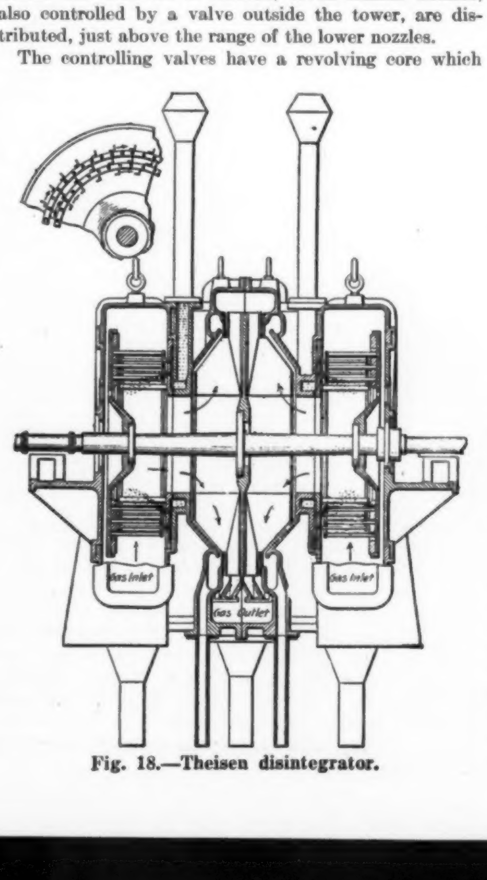


Fig. 18.—Theisen disintegrator.

successively blocks off the opening to the different nozzles, thereby temporarily stopping the flow of water and creating an area of low pressure directly above the nozzle. When the core has passed, the flow of water resumes through this nozzle and sprays the gas which has reached this point. The core is revolved electrically, at the rate of about 15 revolutions per minute, and a 5 horse-power motor is ample to operate four valves, which are sufficient for two towers.

The screens, which are placed above the nozzles, break up the water into fine drops, permitting intimate contact of the gas and water.

In the operation of these towers at Duquesne, the gas rises through the scrubber at the rate of 4 feet per second, and the water at the rate of 60 feet per second with a head of 35 pounds main pressure. The gas is cooled down very effectively, the temperature of the outgoing gas being only from 5 deg. to 6 deg. Fahr. above the temperature of the incoming water, while the moisture content averages only about 0.5 grain per cubic foot above the saturation point at the temperature of the outgoing gas.

BIAN GAS WASHER.

The Bian gas washer, as shown in Figs. 14 and 15, consists of a stationary horizontal steel cylinder through which the gas passes from one end to the other. Inside the cylinder, there slowly revolves a shaft which carries a number of vertical disks consisting of wire netting of fine mesh. The diameter of these disks is very slightly less than the inside diameter of the cylinder, and this arrangement necessitates the gas passing through the openings in the screens as it travels through the apparatus. The screens, to the extent of nearly half their diameter, dip into the water contained in a trough upon which the open bottom of the cyclinder rests, and as the shaft revolves, the part of the screens which has been immersed rises from the water with the meshes covered with thin films of water, thus allowing thorough contact with the gas as it passes through the perforations.

FINAL WET CLEANING.

(Some of these systems can also be applied to primary cleaning).

The amount of cleaning accomplished in Zschocke and similar towers, and in the Bian washer, while satisfactory for stoves and boilers, was found to be not sufficient when the gas was destined for use in gas engines, and the systems of Theisen and Schiele were developed for this purpose.

THEISEN GAS WASHER.

The Theisen washer, as shown in Figs. 16 and 17, consists of a casing lined with a special wire netting, within which revolves at high speed, a drum carrying numerous fan blades set at oblique angles to the axis of rotation, these blades or vanes being so fitted that they form a continuous spiral curve. This allows the gas to be drawn in at one end of the casing and expelled at the other end. Water is admitted at the side of the casing and is converted into a fine spray by the revolutions of the blades, and the spiral arrangement of these

blades causes the spray to flow in the opposite direction to the gas, which passes through this spray, being simultaneously cleaned and cooled. The dirty water leaves the apparatus by a water seal at the bottom.

The Theisen and Schiele systems of final wet cleaning have for years given very satisfactory results, but are now being gradually superseded by systems requiring less capital expenditure and less operating expense. Most of these systems can be used for primary cleaning as well as for final cleaning, by installing in two stages. The most important of the wet cleaning systems which perform as efficient cleaning with the consumption of much less power and water than the Theisen and Schiele systems, are the disintegrator system of Theisen, the disintegrator system of Schwarz-Bayer, the Fowler & Medley rotary washer, and the Feld rotary washer, while the Halberger-Beth dry cleaning system of filtration through canvas is remarkably efficient in cleaning and is cheap to operate. Following is a detailed description of each of the systems mentioned, together with several other modern systems:

THEISEN DISINTEGRATOR GAS WASHER.

There are two styles of Theisen disintegrator gas washers. One style consists of a casing in which the gas enters by two apertures at the base of the apparatus and is washed by a spray of water in a perforated drum or cage equipped with vanes, the drum revolving within a stationary drum, the gas being drawn through the apparatus by a fan mounted on the same shaft and discharged with the necessary pressure to carry it to the point of consumption. The second style also has the fan mounted on the shaft, but the fan is inclosed within the disintegrator.

The Theisen disintegrator consists of a series of rotary and stationary perforated drums or cages arranged concentrically within one another, as shown in Fig. 18. The stationary drums consists of round bars and the revolving ones of angle bars. The hot raw gas enters the apparatus at the bottom, meets the effluent water and undergoes a preliminary cooling and cleaning in the lower part of the machine. The gas is drawn in counter-current through the series of rotary and stationary drums by means of a fan. The water is converted into a fine spray by the centrifugal action of the rotating drums, and the gas, passing through this spray, is cleaned. The fan is located in the same casing and on the same shaft as the rotary disintegrating drums, the shaft being direct motor driven. Fresh water is introduced into the innermost rotating drums in the form of a finely divided spray.

The cooling and cleaning of the gas and production of the pressure necessary to conduct the clean gas to its point of consumption are all performed in one apparatus and with one motor. It is stated that this disintegrator is an improvement over the former Theisen apparatus, requiring much less power and water, and performing the necessary cleaning of the gas without preliminary towers.

(*To be concluded.*)

"Twilight Sleep" in the Light of Day*

SOME very excellent lay magazines, and some equally good professional ones, have been taking somewhat opposite sides in a discussion of "painless childbirth," according to rules laid down by Drs. Kroenig and Gauss, physicians-in-charge of the maternity clinic, Baden University, Freiburg, Germany.

The treatment is practically an adaptation to obstetrics of Crile's anoci association, that is, it is partly psychologic and partly the administration of drugs to the point of semi-narcosis with the aim of eliminating the memory of pain.

Absolute quiet and very soft light in the lying-in chamber is insisted upon. One hypodermatic injection of narkophen, which is claimed to be less toxic than morphin, is given, and an hour later a first injection of scopolamin into the muscles of the lumbar region. Small doses of scopolamin are repeated at intervals, according to the length of the labor, usually about five doses being given. Advocates of the method claim remarkable results. A few institutions which are properly equipped for the work in the United States have given it sufficient trial to demonstrate that "twilight sleep" *does* act to abolish memory of pain and may be practised without marked danger to mother or child, *but only with every institutional precaution.* Gentlemen who have tried out the German technic do not recommend it as a safe procedure under the usual conditions of a general obstetric practice. Except for the abolition of the memory of pain, and as a luxury to women in confinement, there is, thus far, no sustained claim that the method presents any tangible advantages in the average case of obstetrics.

On the other hand, opponents are severe in their condemnation, claiming danger of the child being asphyxiated, prolongation of labor, and excessive hemorrhage. But perhaps the question of medical ethics involved as regards the kind of publicity employed in exploiting the method had some bearing upon opinion rather sharply expressed.

Despite the fact that medical journals generally were quick to denounce the methods of Kroenig and Gauss, the same journals were equally prompt in commending the made-in-America "twilight sleep," as recommended to be placed in the hands of every doctor who cares to purchase tablets of morphin and hyoscin.

Now, despite many unfavorable reports upon morphin and hyoscin in labor—the journals were full of it a few years ago—there are many physicians using these drugs and claiming good results. They must have a reason for it, just as others have a reason against it. But merely giving morphin and hyoscin is not practicing the "twilight sleep" method; no, not even approximating it!

The fact is that racial differences should modify our obstetric practice, as women of different races present differing problems. No hard and fast rules can be laid down. Some women of neurotic tendencies—pampered, petted, unaccustomed to the hardnesses of life—will welcome the German technic of "twilight sleep." One can readily understand that the method has a legitimate application among a certain class. Also these women should be confined in a special institution, where they can *safely* have the balm of "twilight sleep." And one can understand readily enough that the hard-headed country physician sometimes has cases in which morphin and hyoscin will serve him and his patient. True, if he uses these potent drugs, he should remain a longer time with the patient—charging for his time—so as to be on the safe side, and he should not overdo the dosage. But he should not bluff. Giving a dose or two of morphin and hyoscin is not "twilight sleep," any more than the common but unscientific custom of giving a hypodermatic dose of morphin before anesthesia is "anoci association."

And the blunt fact remains that neither "twilight sleep" nor the administration of morphin and hyoscin in labor is good practice as a routine procedure. Most women need neither one of them. The obstetrical authorities who are opposing these methods are not doing so from mere crankiness.

SURGERY AND ANESTHESIA.

There is a popular demand upon the doctor to "stop this pain!" After all, most of the doses of narcotics we give are given, not because we think the patient needs the narcotic, but because he will promptly go to another doctor if we refuse. This editor may preen himself upon his virtue because he point-blank refuses a narcotic nine times out of ten it is asked for, and loses practice by the many refusals; but the Scotch are good refusers, and it may be bluntness more than virtue. But whatever it is, it saves many a man and woman from themselves. That is part of a doctor's job.

The surgeons are responsible for much of this craze for pain-stopping. Incising a boil for a dollar has given way to the ten-dollar, local-anesthesia surgical operation. "Painless dentists" have the call. Blisters are out of date, principally because they hurt. The man who invents "painless vaccination" will have the anti-vaccinationists on the run in short order. Women who have hair removed from their faces by the electric needle method are now demanding that cocaine first be applied. It is the pain and annoyance that keeps many women from nursing their babies. Ear-rings have gone out principally because it hurts to pierce the ears. Men are not a bit better. Every headache must be "stopped" by a dose of poison and we must soothe our nerves with several cigars a day. Fie on us! We are becoming soft. And modern surgery is helping along in the craze for "stopping" pain.

Is it to be wondered at that women are asking why it is that normal labor is being made a matter of elaborate surgical technic and without any form of anesthesia, whereas in other surgical work she is fully anesthetized? Years ago, before a labor was regarded as a surgical crisis, ether was given, and we are being asked why its use was nearly abandoned in the lying-in room.

But physicians know the danger of semi-anesthesia. Maybe we have exaggerated these dangers. Certainly we have devised no way to overcome them. And yet it would seem that, in the supreme crisis of a woman's life, there *should be* a way. Let us try to find it. "Twilight sleep" may be a beginning. So, instead of denouncing it, let us try to find out its weakness. Personally disappointed in all methods of anesthesia or semi-anesthesia we have employed in labor, and not at all inclined to view hyoscin favorably, yet we feel that *a way* should be found, even if it is simply some modification of or improvement upon present methods. Meanwhile, let us be charitable to the physicians who advocate "twilight sleep" and hyoscin. If we discover some better way, then our condemnation will come with better grace.

PAIN AND EUGENICS.

But a few general considerations must not be forgotten. If we are to retain our regard for the well-being of the race at large, we will not allow ourselves to be swept off our feet by the ultra-modern fear of pain and the craze for narcotics. Sex consideration is admirable in its way; but child-bearing is not a matter of ordinary sex consideration, because *the race*, not merely the female sex, is most vitally involved in it.

Of course, it is a trial for women to face child-bearing and its pains. Every proper effort should be made to mitigate these trials. But if eugenics means anything vital to the modern women, she will not act the coward and menace the safe conduct of the important function of child-bearing. She will seek for a remedy, but she will also face the issue whether a remedy is found or not.

* The *Medical Council.*

Fastening Metals to Marble

A CEMENT for fastening metal parts to marble, as in the case of an electrical switchboard, which should be most useful, is given in the *American Machinist*. It consists of thirty parts plaster of paris, ten parts of iron filings, and half a part of sal-ammoniac. These materials are intimately mixed and then acetic acid is added to make a thin paste, which must be used immediately after mixing.

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